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Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

ALBERTA MUNICIPAL AFFAIRS
PROPOSED SUBDIVISION
FORT CHIPEWYAN, ALBERTA
GEOTECHNICAL CONDITIONS

EG-06558 APRIL 11, 1988

PREPARED FOR:

Alberta Municipal Affairs
Fort McMurray, Alberta

PREPARED BY:

Hardy BBT Limited
Edmonton, Alberta

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1.0 INTRODUCTION

At the request of Mr. Leo Bourassa, Manager for Improvement District No. 18 (North), Hardy BBT Limited undertook a geotechnical investigation in an area of Fort Chipewyan which will be developed for both commercial and residential use. The work was undertaken in accordance with a Professional Services Agreement dated March 8, 1988. The terms of reference were set out in a letter from DelCan Western Limited (undated) signed by Mr. G.D. Price, Manager, Land Development and Planning.

Fort Chipewyan lies on the west end of Lake Athabasca and on the north shore in Township 112, Range 7, West of the Fourth Meridian.

Fort Chipewyan lies within the zone of discontinuous permafrost (Brown, 1970). Because the occurrence of permafrost is sporadic in this area, it is only found where the original tree cover of spruce and a thick organic surface cover are undisturbed. At the locations investigated for this report, the organic cover is thin and problems due to permafrost can be discounted.

The geology has been mapped by Bayrock (1972) and has also been reported in Preliminary Soil Survey Report 63-1 (Lindsay et al) 1963.

Fort Chipewyan lies on the southern edge of the Canadian Shield. The bedrock, which is very close to the surface over most of the settlement, is of granitic rocks. The surficial soils consist mainly of outwash sands, which are generally fine grained, with some clay till. The sand was deposited by meltwater during the retreat of the ice sheet at the end of the last Ice Age. The topsoil is generally thin and poorly developed.

Outcrops of granite are fairly common close to Fort Chipewyan.

The outwash sands have tended to mask the original granite topography by filling in hollows and depressions. At the locations of the 19 boreholes drilled for this project, the maximum difference in the ground surface elevation was 15.4 m in a horizontal distance of over 300 m for a maximum gradient on the site of less than 5 percent. The highest point was found at Borehole 11 (109.8 m) and the lowest point at Borehole 9 (94.4 m). The area planned for residential

development contains the highest land on the site with the elevation being about 6 to 10 m above the ground in the Commercial Area.

Figure 1, Appendix A, shows the locations of the boreholes. In each case, the figures next to the borehole refer to: borehole number, ground surface elevation, depth to bedrock.

2.0 DRILLING, SAMPLING AND TESTING

Nineteen boreholes were drilled on March 12 and 13, 1988 using a truck-mounted continuous flight auger. The locations of the boreholes are shown on Figure 1, Appendix A. The logs of the boreholes are also shown in Appendix A. The following sampling and testing procedure was followed:

1. Disturbed samples were taken at maximum depth intervals of one meter for water content determinations in all boreholes.
2. Standard Penetration Tests were performed in many of the boreholes as indicated on the borehole logs. Soil from the penetrometer tube was bagged for testing.
3. All samples were examined visually and classified in the field. An explanation of the terms and symbols used on the logs is in Appendix B.
4. The groundwater conditions were noted during drilling and on completion of the drilling program.

   The elevation of the ground surface at each borehole was found by levelling. The bench mark used was the paved surface of McDermont Avenue at the intersection of the avenue with Henry Drive. This point on the road has an assumed elevation of 100.00 m.

   Laboratory testing was carried out in our Edmonton laboratory. Results of all tests are shown on the borehole logs. Soil samples which were not tested will be stored for a short period and then disposed of.

3.0 SOIL PROFILE

The soil profile consists almost invariably of topsoil, sand and granite bedrock. In a few holes (such as Borehole 6) clay was also found. The clay was probably laid down by the ice sheet during a temporary re-advance at the end of the last ice

age after the ice sheet had retreated once from the Fort Chipewyan area.

3.1 TOPSOIL

Topsoil was encountered in most of the boreholes and was generally quite thin with the thickness seldom exceeding 150 mm. In some cases, the topsoil had been removed during the clearing of trails in the area.

3.2 OUTWASH SAND

The soil profile between the topsoil and the bedrock is almost entirely sand which is generally fine grained and silty.

As this material was laid down by running water, it has been sorted to some considerable extent. No cobbles or boulders were found in this material but the possibility of finding large rocks within the outwash sand should not be entirely discounted as large rocks could have been washed from the melting ice sheet when attached to blocks of ice.

The sand is generally dense to very dense, as shown by the blow counts in the Standard Penetration Tests, and water contents are very low, with many samples showing water contents of less than 2 percent, except at greater depth where some of the sand is saturated.

3.3 CLAY

Clay was found in Boreholes 6, 8, 12, 13, 16 and 18. The clay is of medium to high plasticity showing that it was not derived from the local bedrock.

3.4 BEDROCK

Bedrock was encountered in several of the boreholes with the minimum depth to bedrock being 0.6 m in Boreholes 9 and 11. As noted above, the bedrock is granite. The surface of the bedrock is often fractured but the fractures are usually quite shallow.

3.5 WATER SOLUBLE SULPHATES

Ten tests to determine the concentration of water soluble sulphates showed concentrations of 0.01 percent in every case expressed as a ratio of water soluble sulphates to dry weight of soil.

4.0 GROUNDWATER

Water was encountered only in Boreholes 12 through 15. Because the area is well drained, and the soils are pervious, water is not expected within the depth of expected excavation except following spring breakup or periods of heavy precipitation or in places where hollows in the bedrock serve to trap the water.

5.0 DISCUSSION AND RECOMMENDATIONS

In general, the foundation conditions in the area are good. The two factors of greatest concern will be the cost of excavating through the bedrock and the considerable depth of frost penetration which can be expected beneath streets and roads clear of snow.

Excessive excavation for buried utility lines through the granite could be avoided, or reduced, by avoiding the higher parts of the site in the residential areas.

5.1 FROST PENETRATION

The Mean Annual Freezing Index for Fort Chipewyan is estimated at 2780 degree days Celcius. For return periods of 25, 50 and 100 years the values are 3150, 3330 and 3450 degree days Celcius, respectively (McCormick, 1971). Assuming that a return period of 50 years is used, the depth of frost penetration in the sand and granite at the site is estimated to be 4.4 m.

The depth of frost penetration in dry sand or rock cannot be accurately calculated because of the overriding influence of the water content in the soil. Where the water content is very low, the calculations are approximate. It is therefore suggested that a maximum depth of frost, beneath cleared streets, be assumed to be 5.0 m.

Actual measurements of frost penetration beneath airport runways have been carried out by Transport Canada at a number of airports. The data for six airports are shown on Figures 2 through 7 of Appendix A. Both Whitehorse and Yellowknife airports are built on sand and gravel and the depth of frost, and rate of penetration, would be similar to the conditions found at Fort Chipewyan for a given freezing index. The remaining examples are for comparison.

The frost penetration beneath a snow cover is much less than beneath cleared or travelled areas. Figure 9, Appendix A, shows a summary of measurements made at 36 Canadian Airports. It will be seen that the penetration beneath a snow cover for granular soils is about 60 percent of the penetration beneath a cleared area. Reliance on the snow cover to retard frost penetration is only suggested for areas which will definitely not be open to cross-country vehicles.

5.2 EXCAVATIONS

Excavations in the sand and clay for house basements will not present any unusual problems. The slopes in the soil can be cut back to some safe angle which is estimated to be about 1.0 horizontal to 1.0 vertical. Where the depth of an excavation is less than 1.5 m and the width at the bottom of the excavation is more than this distance, there will be little danger to workers.

Excavations for service trenches will require more care both in planning and execution. Because there is a much greater danger of workers being trapped in trench excavations than in excavations for house basements, a more conservative approach is recommended. The side slopes for trenches greater than 1.5 m in depth should be cut back so that they are no steeper than 1.5 horizontal to 1.0 vertical or steeper slopes may be used and a moveable shield used to protect workers in the trench. Another alternative is to have the sides of trenches shored and braced but such temporary supports are unlikely to be economical in this case.

Contractors should be warned that locations where sand is found below a clay layer often prove to be unstable and care should be taken in these cases. Also, wet sand may be encountered in deeper trenches.

Temporary surcharge loads, such as stocks of materials, should be kept back from excavated faces a distance equal to at least one-half the depth of excavation. If this is not possible, the extra load should be considered when designing bracing. Vehicles delivering materials should be kept back from excavated faces by at least 0.6 m.

The latest edition of the Construction Safety Regulations of the Occupational Health and Safety Act of Alberta should be followed.

5.3 BURIED UTILITY LINES

The depth of frost penetration which should be expected below cleared streets or roads has been mentioned in a previous section. To place buried water lines below the depths of maximum frost penetration, on a 50 year design basis, would require at least 4.2 m and, preferably, 5.0 m of soil cover above the top of the pipe. Such a depth of burial for water lines would be expensive. An alternative approach, which has been used in similar situations, is to place the buried water lines within the depth of expected frost penetration but to insulate the lines and heat the water.

Figure 8, Appendix A, shows the relationship of the freezing index at depth versus the freezing index at the ground surface based on work published by Sanger (1963). It will be noted that the freezing index at depth rapidly attenuates. For example, if the maximum depth of frost is assumed to be 5 m, the freezing index at a depth of 2.0 m (40 percent of the maximum frost penetration) is only 20 percent of the freezing index at the ground surface. If the 50 year design period for the air freezing index of 3330 degree days Celcius is assumed, the freezing index at the ground surface would be 90 percent of this value or 3000 degree days Celcius. The frost penetration depth can be calculated by using the Modified Berggren Equation as given by Aldrich (1956) as 4.8 m assuming the density of the sand as 1600 kg per cubic meter and a water content of 2 percent. The freezing index in the soil at a depth of 2 m would be 20 percent of the ground surface freezing index or 600 degree days Celcius. The minimum soil temperature at this depth is estimated at -8 degrees Celcius. This minimum soil temperature would be in effect for only a short time during the winter.

These various relationships could be used to calculate the heat loss from buried water lines to arrive at an economic "trade-off" between the cost of deep burial of water lines, without the need for insulation or heating the water, versus burial at shallower depth and the need to provide heat and, possibly, insulation.

5.4 PIPE BEDDING

Because the sand at the site is susceptible to disturbance by construction equipment, it will be necessary to pay particular attention to the preparation of bedding for buried pipes.

It is suggested that trenches for buried water or sewer lines be over-excavated by a distance of about 150 to 200 mm and the

bottom of the trench brought up to desired grade using compacted pit run gravel or crushed rock.

In the case of trenches excavated in rock, the depth of over-excavation should be at least 300 mm below pipe inverts in order to provide a "cushion" below the pipe.

Pit run gravel should have a maximum size of 50 mm with the proportion passing the 5 mm sieve lying between 30 and 70 percent and the proportion passing the 75 micron sieve lying between 4 and 10 percent.

Alternatively, crushed rock or clean gravel could be used. In this case, there is a possibility of the fine sand migrating upwards into the gravel and thus causing loss of support. To prevent migration of the fine material, the crushed gravel or rock and the native soil should be separated by a non-woven geotextile. Any non-woven geotextile can be used for this purpose.

The gravel bedding should be thoroughly compacted using a double-drum vibrating roller which should make at least four passes.

On top of the gravel bed can be placed sand bedding in the usual manner. The sand bedding, after placement of the pipe, should be brought up around and on top of the pipe and lightly compacted.

5.5 BACKFILL COMPACTION

If paved streets or roads are to be placed on top of backfilled trenches within two years of placement of buried utilities, it will be necessary to compact the backfill in the trenches to a fairly high standard. Care should be taken that there is sufficient thickness of soil above buried pipes to protect them from the effects of compaction equipment. This thickness of soil will depend on the weight and type of compaction equipment the contractor elects to use and the material of the pipe. It is suggested that the absolute minimum thickness of soil above a pipe be 0.6 m and this thickness should be increased after considering the weight and type of equipment to be used and the material of the pipe.

Once the level of the backfill has reached a safe height above the top of a buried pipe, the backfill should be thoroughly compacted in lifts of maximum thickness of 200 mm using vibrating rollers of a minimum static weight of 8 tonnes.

The sand should be compacted to the equivalent of at least 99 percent of maximum standard Proctor density (ASTM Method D-698). Control of the water content in the soil during compaction will be critical.

The last 300 mm of fill beneath a pavement structure should be pit run gravel meeting the gradation sizes mentioned in a preceding section.

If the roads or streets are not to be paved for more than 2 years, or if the streets will be finished with gravel, the standard of compaction of the backfill can be relaxed to 95 percent of standard Proctor density and the thickness of each lift can be increased to 300 mm. Settlement of nominally compacted backfill should be assumed to be 5 percent of the total depth of the trench.

5.6 ROAD SECTIONS

Roads designed with a "Rural" section should have side slopes no steeper than 3 horizontal to 1 vertical. If there is sufficient space, the slopes should be flatter than this angle in order to encourage the growth of grass and to facilitate snow removal.

The vertical distance from the crown of the road to the bottom of a ditch should be at least 600 mm with a depth of 1 m being preferable.

Material for road embankments should be compacted as described for backfilling in utility trenches.

5.7 SOIL EROSION

The sand at the site is fine grained and is susceptible to erosion by both running water and wind. It is noteworthy that sand dunes have been reported in the area of Fort Chipeywan as described by Lindsay et al (1963).

Erosion could best be inhibited by planting grass, shrubs and trees. Species which are native to the area and which have deep and extensive root systems are preferable.

Shallow slopes will aid in the cultivation of vegetation and will also help to reduce the effects of running water.

There are numerous bio-degradable materials on the market which can be used to stabilize soil surfaces while vegetation is encouraged.

5.8 HOUSE FOUNDATIONS

Conventional house basements will be suitable in this area. Where the depth to bedrock is very shallow, as in the vicinity of Borehole 11, excavating for basements will be expensive. In this situation, it may be more economical to use a crawl space or a slab-on-grade floor and provide extra room on the main floor in lieu of a basement.

Strip and spread footings in the sand and clay can be designed on the basis of an allowable soil bearing pressure of 200 kPa. Because the sand is easily disturbed by construction equipment as noted in the section "Trench Backfilling", the bottoms of excavations for house basements should be treated in the same manner as for the bottoms for trenches for utility lines.

The design of basement walls to resist lateral soil pressures can be based on the equivalent fluid pressure method assuming a soil density of 18 kN per cubic meter and a coefficient of earth pressure at rest of 0.5.

Where any service lines pass through the backfill, the backfill below the level of the lines should be thoroughly compacted in order to provide support against settlement of the soil.

Weeping drains should be placed around all basements at footing levels. The drains should be surrounded by clean, coarse gravel or crushed rock. The rock should meet the requirements of CSA A23.1 for coarse concrete aggregate. It should not contain more than 20 percent of material finer than 2.5 mm and no more than 5 percent finer than 1.0 mm.

A non-woven geotextile filter cloth should be used between the gravel or crushed rock and the native soil. The geotextile cloth should be folded over the top of the drainage gravel before backfilling is commenced.

All basements should be heated throughout the winter. If insulation is placed on the outside of basement walls, it is essential that the insulation be suitable for use below grade.

5.9 MISCELLANEOUS

The finished site grading around houses, or other buildings, should be laid out so that surface water is drained away from the buildings as rapidly as possible. Roof and other drains should discharge well clear of buildings or onto splash pads.

All concrete in contact with the soil may be made with normal Portland cement. The minimum compressive strength of the concrete at 28 days should be 20 MPa. Air entrainment should also be used.

The foundation must be kept from freezing both during and after construction. Unless permitted by the engineer the foundation concrete should not be placed on or against frozen soil.

Backfill should not be placed until the structure has sufficient strength to withstand the earth pressures resulting from placement and compaction.

The appendices attached to this report form an essential part of it and should be read in conjunction with the text.

6.0 INSPECTION AND LIMITATIONS

This report is based on the findings at 19 borehole locations. Should different subsoil and groundwater conditions be encountered during construction, this office must be notified immediately and the recommendations submitted herein will be reviewed and revised as required.

The construction of foundation systems should be inspected by a geotechnical engineer or technologist registered in the Province of Alberta.

This report has been prepared for the exclusive use of Alberta Municipal Affairs for specific application to the project described in this report. It has been prepared in accordance with generally accepted soil and foundation engineering practices. No other warranty, expressed or implied, is made.

Respectfully submitted

Hardy BBT Limited

PERMIT TO PRACTICE
HARDY BBT LIMITED
Signature
Date April 26/88
PERMIT NUMBER: P [illegible]
The Association of Professional Engineers,
Geologists and Geophysicists of Alberta

Per:

Reviewed by:
Brian A. Ross, P.Eng.

G. McCormick, P.Eng
Geotechnical Division

GM/cls,6,9:388

REFERENCES

Aldrich, H.P. 1956. "Frost Penetration Below Highway and Airfield Pavements" Highway Research Board, Bulletin 135.

Bayrock, L.A. 1970. Surficial Geology Fort Chipewyan, Research Council of Alberta. (Map).

Brown, Roger, J.E. 1970. Permafrost in Canada, University of Toronto Press.

Lindsay, J.D., Pawluk, S. and Odynsky, W. 1963. Exploratory Soil Survey of Alberta Map Sheets 74-M, 74-L, 74-E and 73-L (north half). Research Countil of Alberta.

McCormick, G. 1971. "Estimation of Design Freezing Indices" American Society of Civil Engineers, Transportation Engineering Journal.

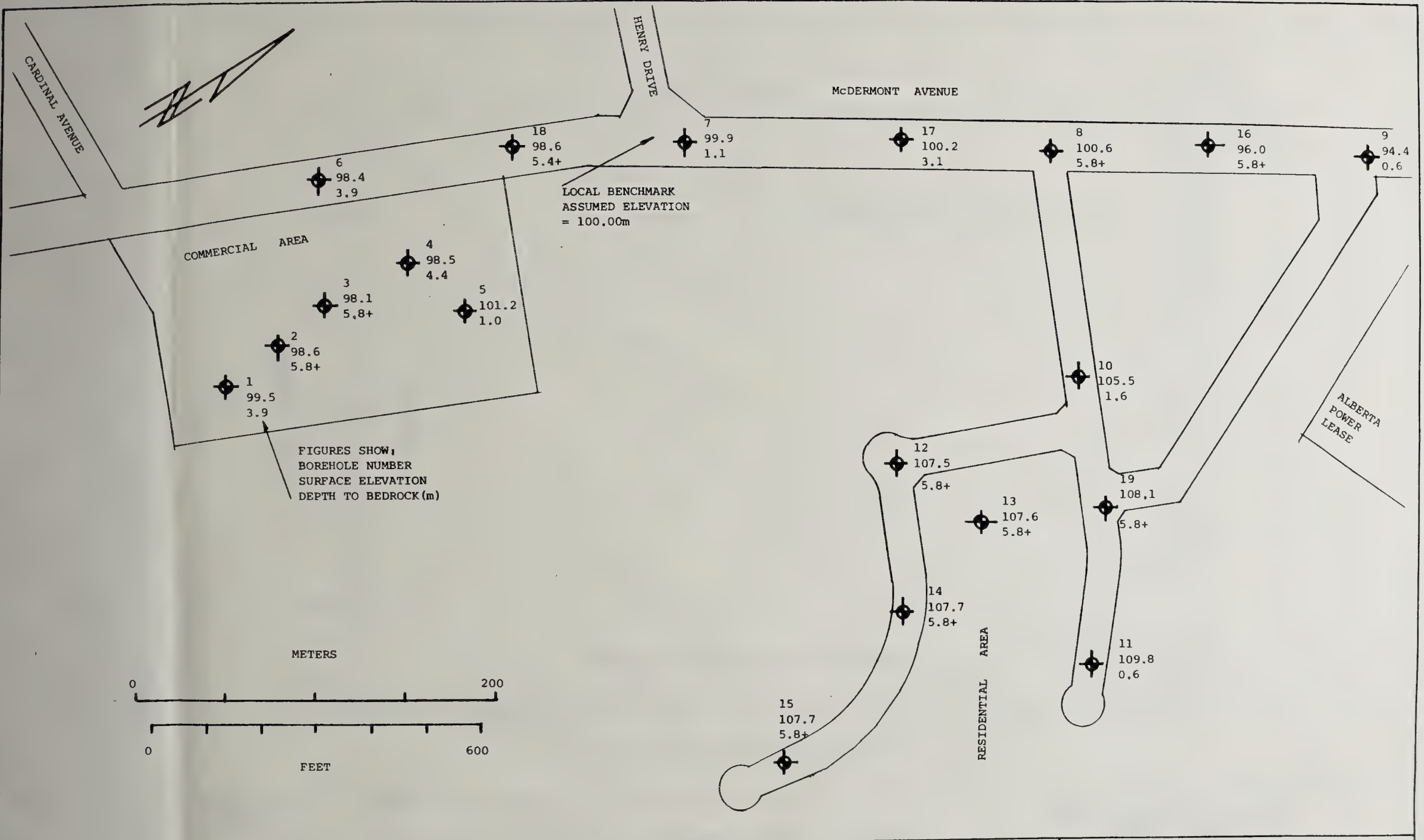
McCormick, G. 1987. "Frost Penetration Beneath a Snow Cover." Proceedings, Second International Conference, Cold Regions Environmental Engineering. Edmonton

Sanger, F.J. 1963. "Degree-days and Heat Conduction in Soils", Proceedings, First International Permafrost Conference, National Academy of Sciences.

Transport Canada 1964-69. Frost Depth Studies at Canadian Airports. Ottawa.

APPENDIX A

Borehole Locations
Charts and Diagrams
Borehole Logs
Laboratory Test Results



REVISIONS

REFERENCES

DELCAN DRAWING 08-1861 Nov 19/87

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DATE April 15/88
MADE GMc
CHKD
APPD

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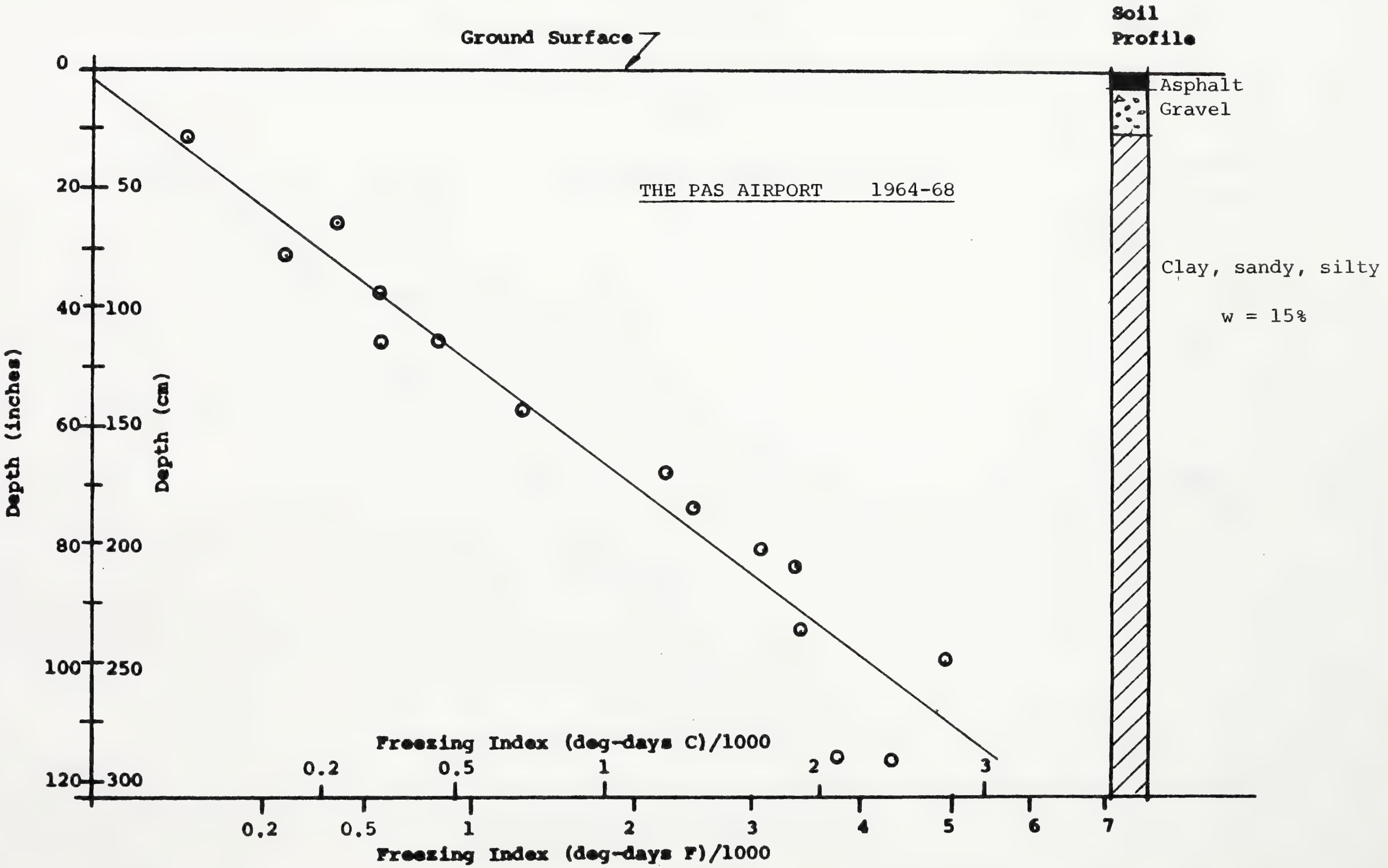
ALBERTA MUNICIPAL AFFAIRS
PROPOSED DEVELOPMENT
FORT CHIPEWYAN

JOB No EG-06558
FIGURE 1



REVISIONS

REFERENCES

TRANSPORT CANADA; FROST DEPTH AT CANADIAN AIRPORTS.

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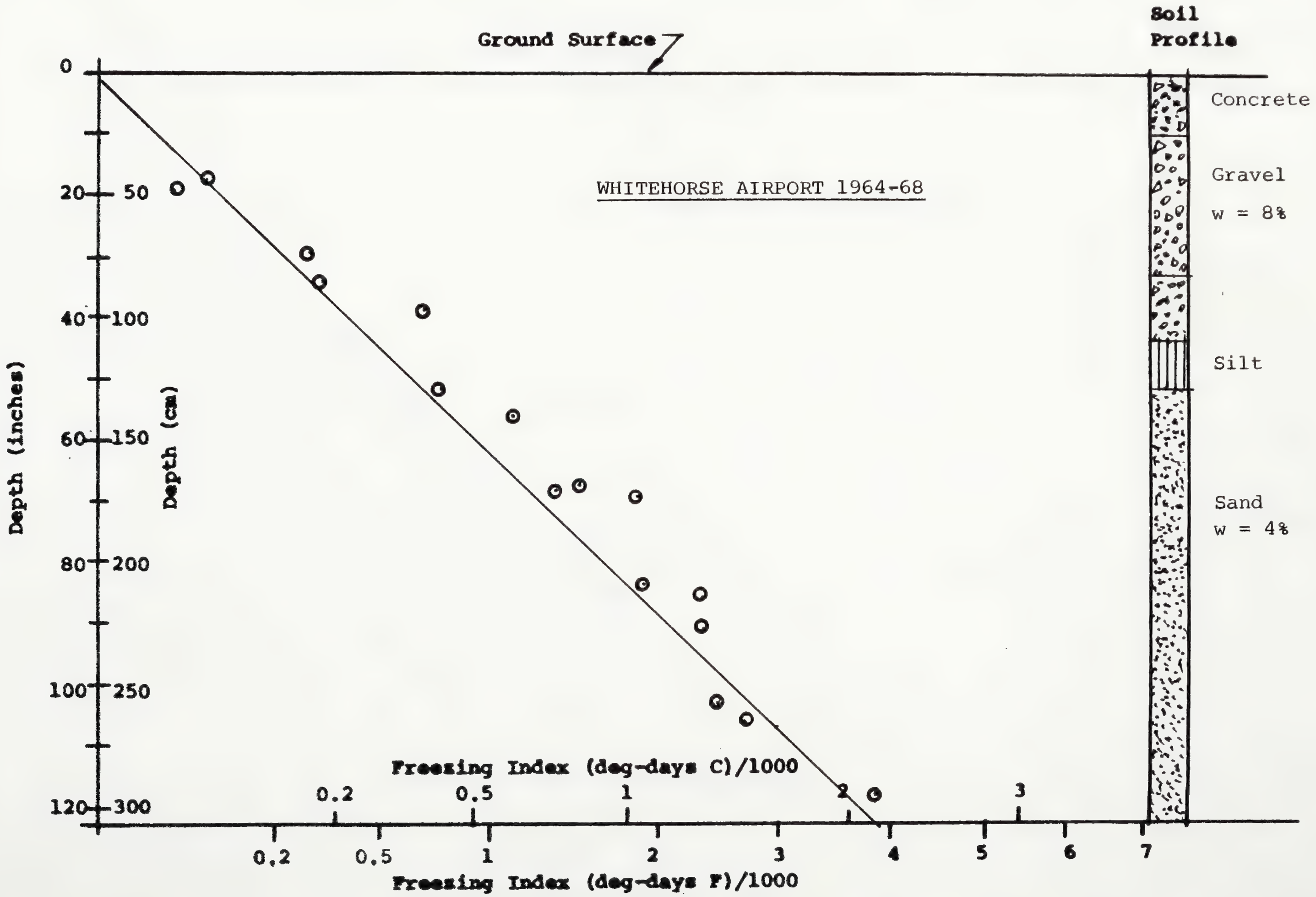
FROST PENETRATION VERSUS FREEZING INDEX

SCALE N/A	DATE April 1/88	MADE GMc	CHKD.	JOB No. EG-06558	FIGURE 2

HBLT 53-87/11



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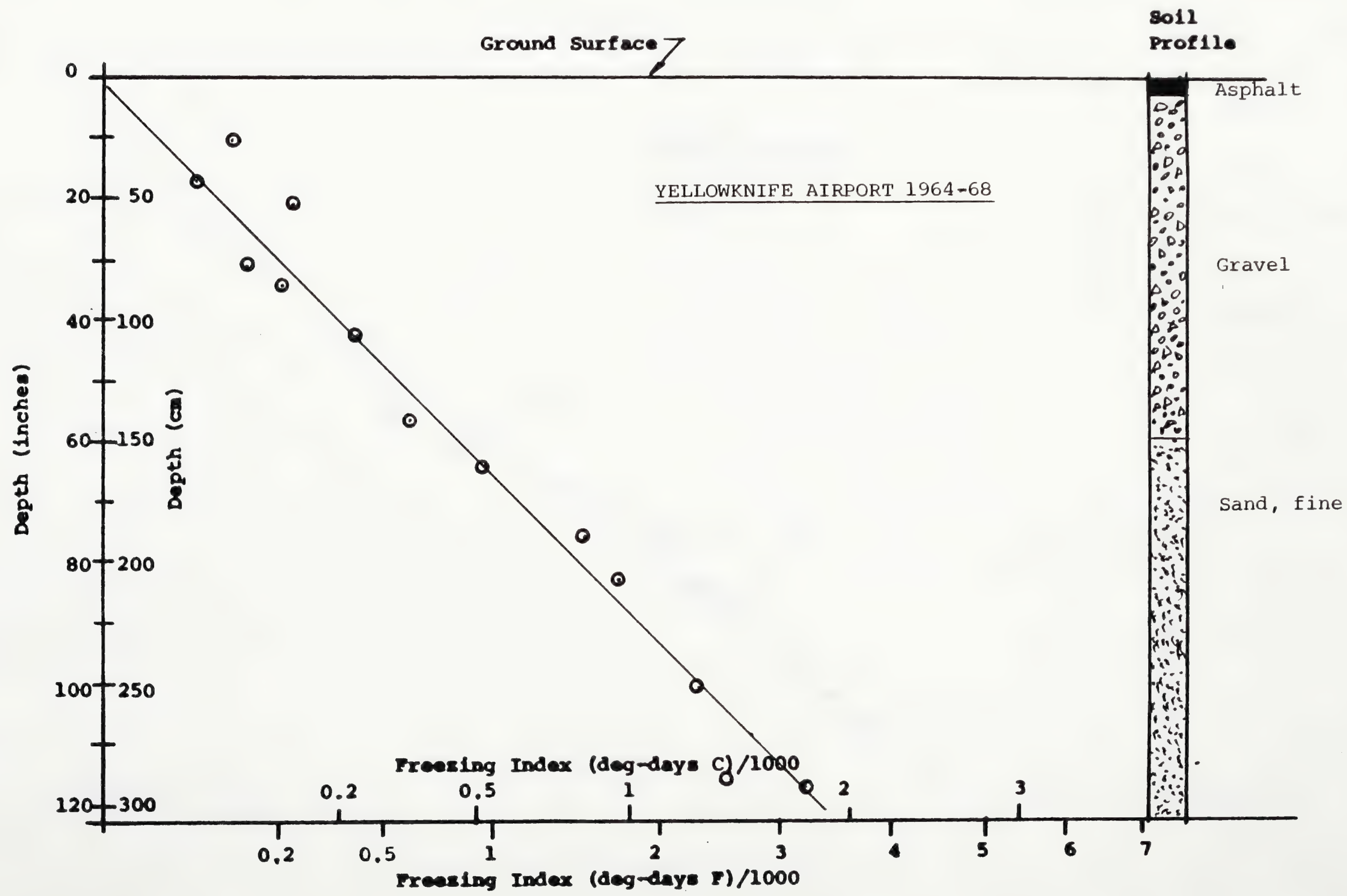
FROST PENETRATION VERSUS FREEZING INDEX

SCALE **N/A** | DATE **April 1/88** | MADE **GMc** | CHKD. | JOB No. EG-06558 | FIGURE 3

HBLT 53-87/11



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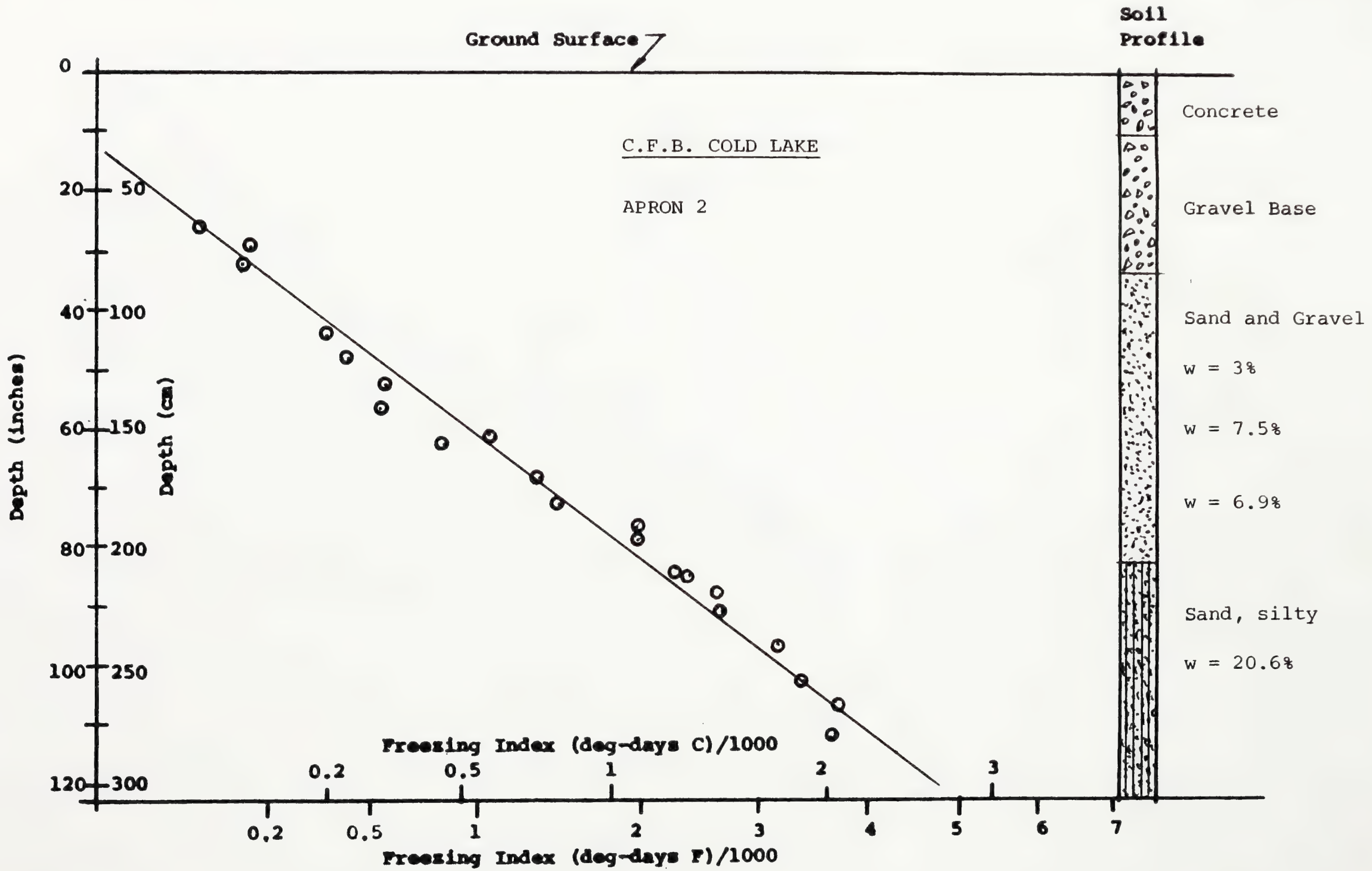
REFERENCES **TRANSPORT CANADA; FROST DEPTH AT CANADIAN AIRPORTS.**		

SCALE N/A | DATE April 1/88 | MADE GMc | CHKD | JOB No. EG-06558 | FIGURE 4



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FROST PENETRATION VERSUS FREEZING INDEX

SCALE N/A
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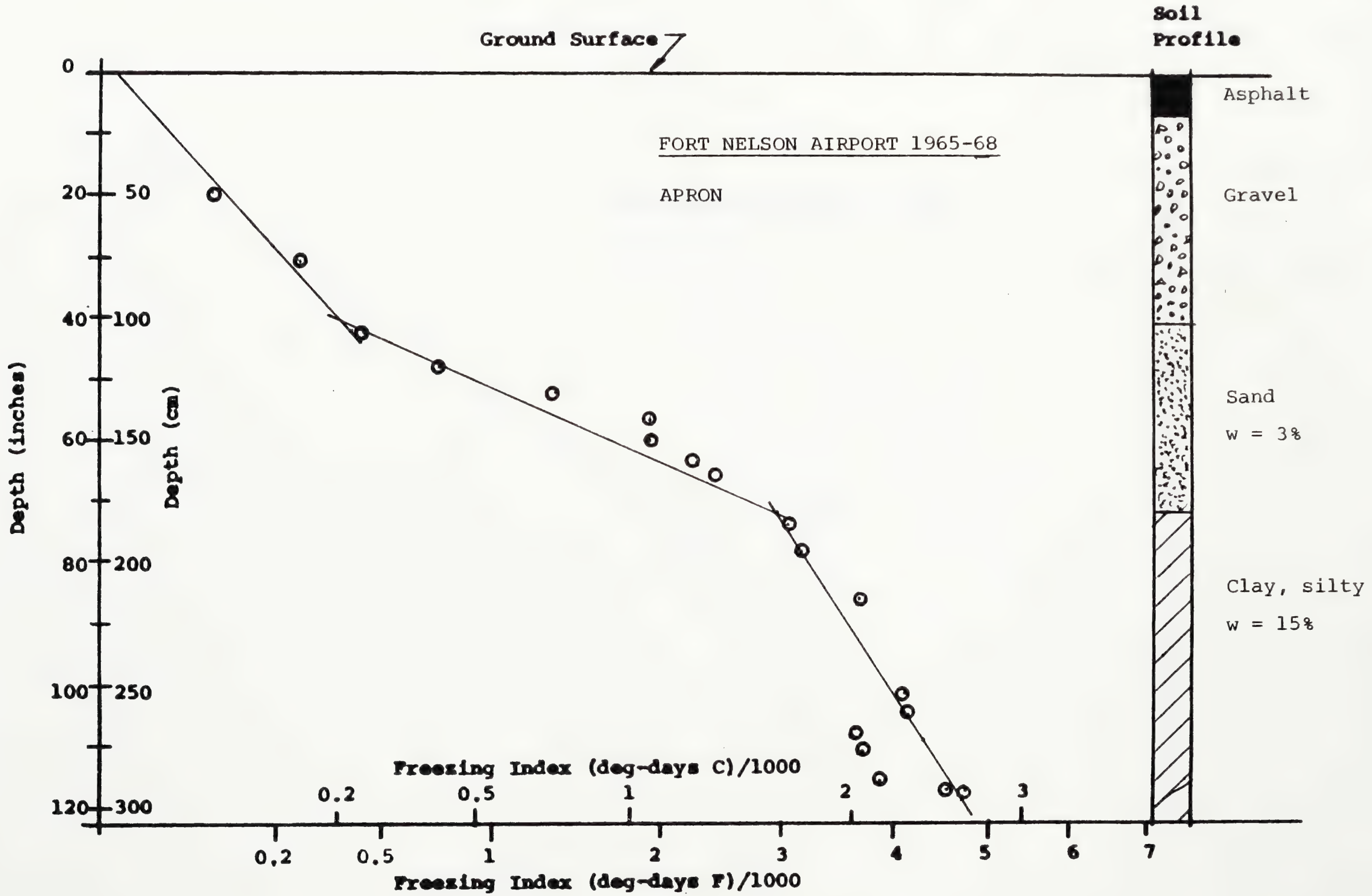
MADE GMc
CHKD.
JOB No. EG-06558
FIGURE 5

HBLT 53-87/11



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FROST PENETRATION VERSUS FREEZING INDEX

SCALE N/A
DATE April 1/88
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CHKD.
JOB No. EG-06558
FIGURE 6

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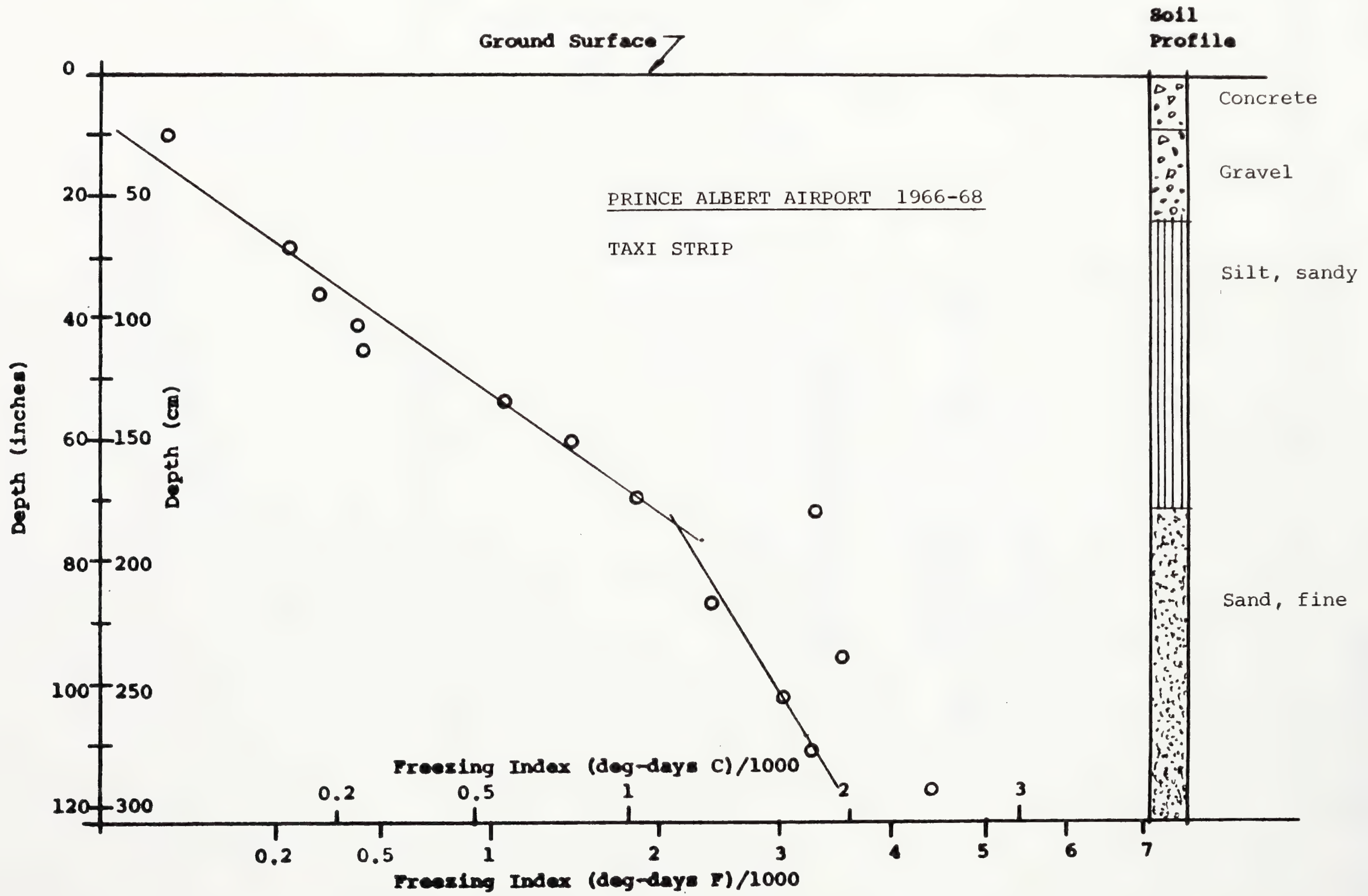

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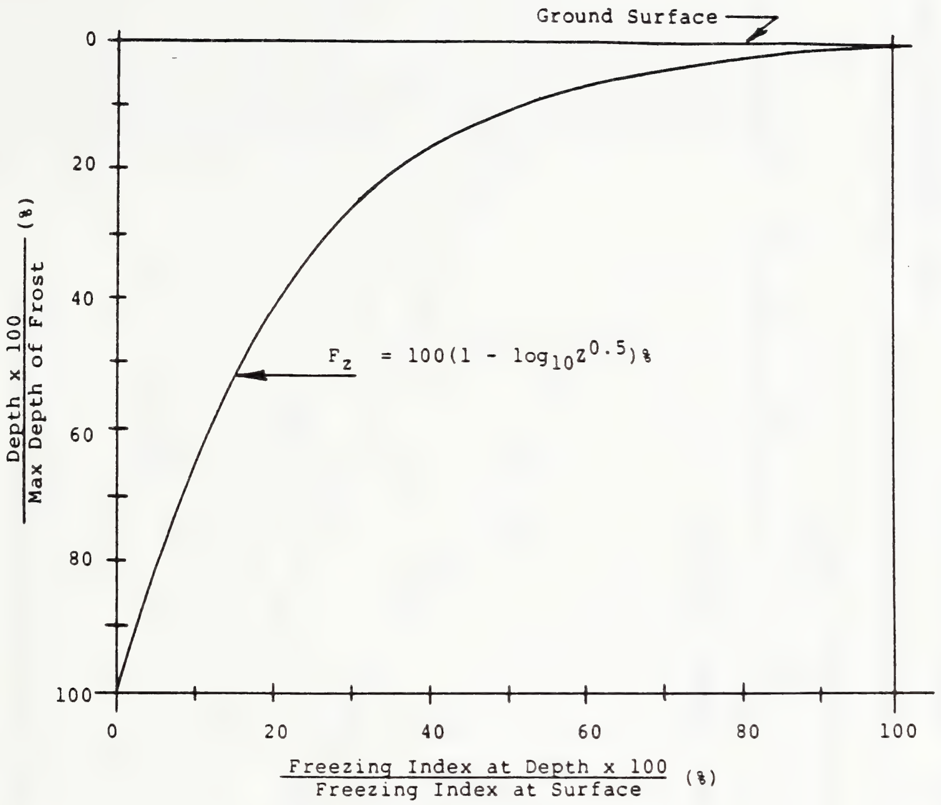
REFERENCES **TRANSPORT CANADA; FROST DEPTH AT CANADIAN AIRPORTS.**		

SCALE N/A | DATE April 1/88 | MADE GMc | CHKD. | JOB No. EG-06558 | FIGURE 7

HBLT 53-87/11



FREEZING INDEX AT DEPTH

VERSUS FREEZING INDEX AT GROUND SURFACE

(After Sanger, 1963)

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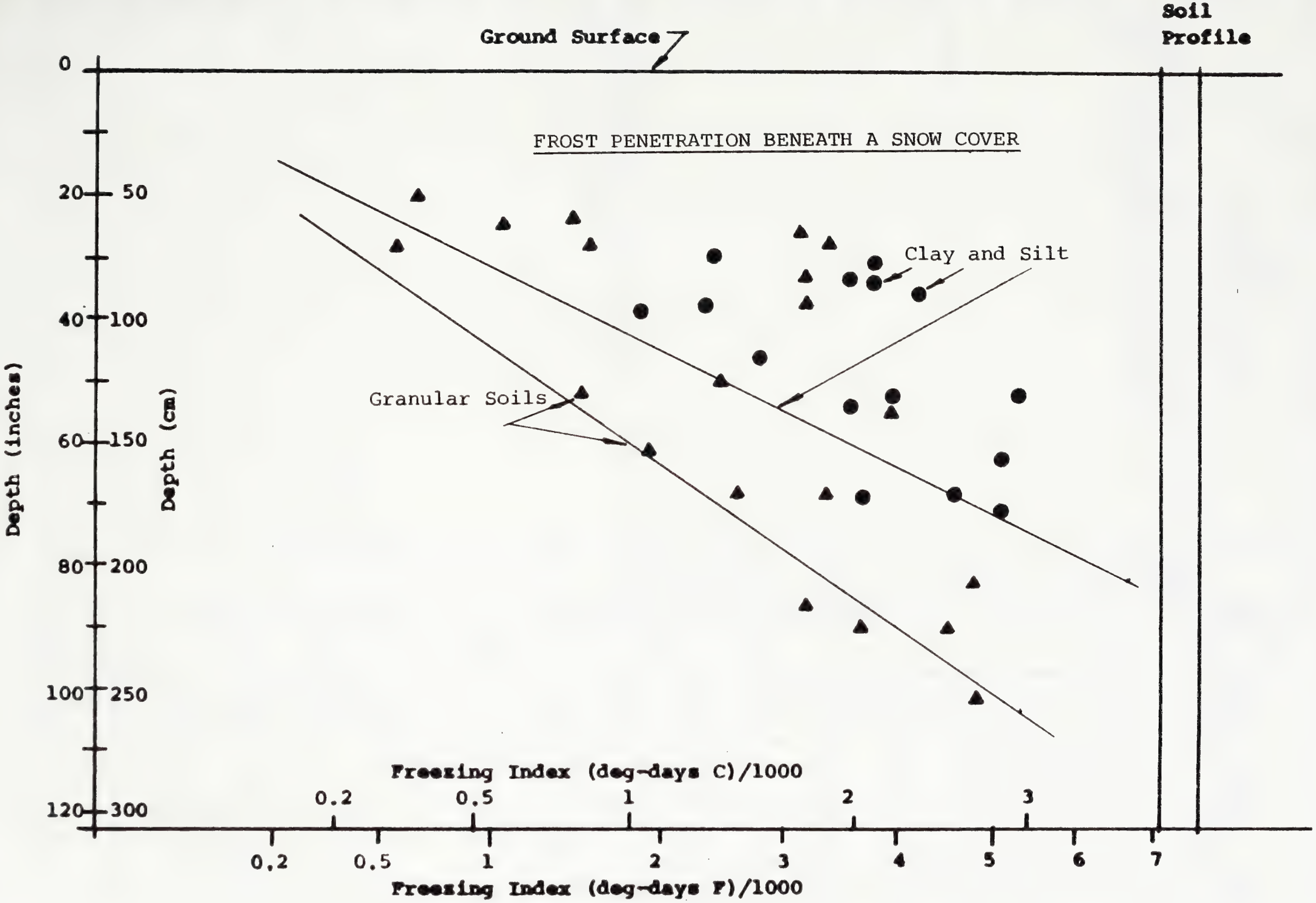
FREEZING INDEX AT DEPTH

SCALE N/A	DATE Apr 8/88	MADE GMc	CHKD	JOB No. EG-06558	FIGURE 8

HBLT 54-87/11



REVISIONS

REFERENCES
TRANSPORT CANADA; FROST DEPTH AT CANADIAN AIRPORTS.

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FROST PENETRATION VERSUS FREEZING INDEX

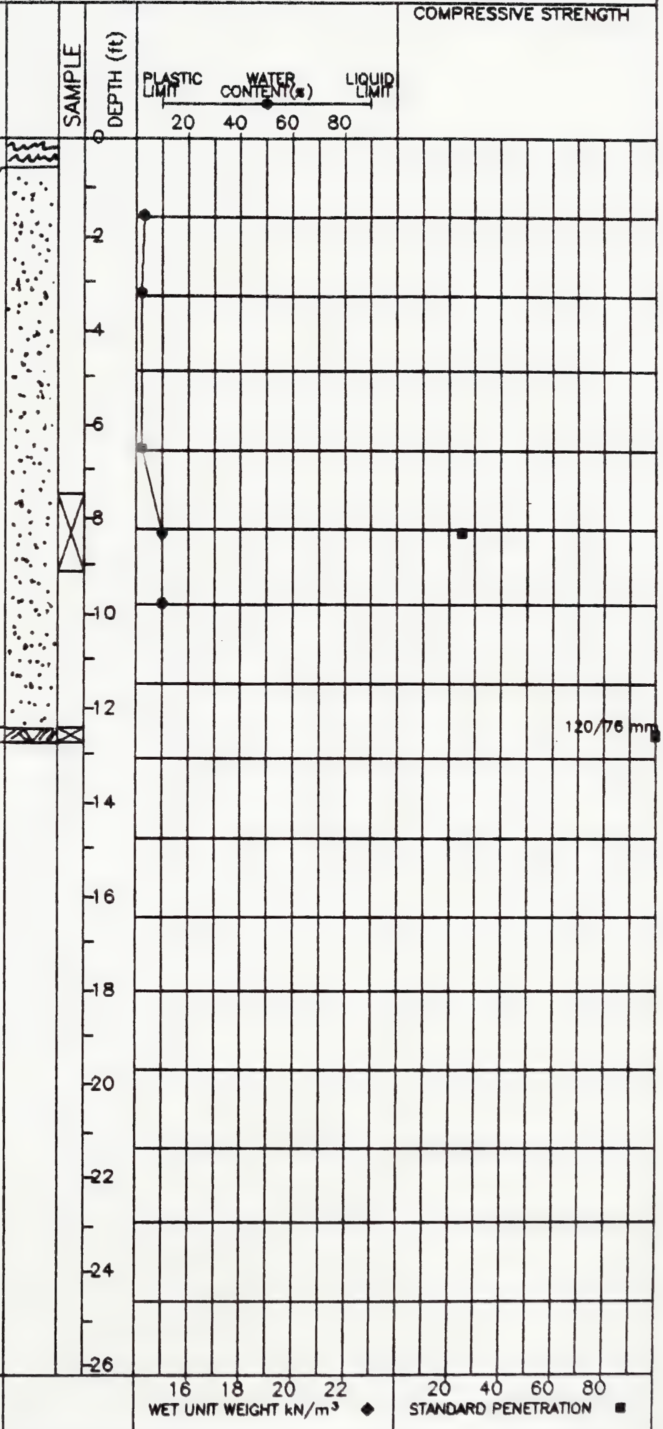
SCALE	DATE	MADE	CHKD.	JOB No.	FIGURE
N/A	April 1/88	GMc		EG-06558	9

HBLT 53-87/11

ALBERTA MUNICIPAL AFFAIRS	BOREHOLE No. 1	EG06558
SUBDIVISION DEVELOPMENT FORT CHIPEWYAN, ALBERTA	RELATIVE ELEVATION 99.5 (m) TRUCK B61, SOLID STEM AUGER	

SAMPLE TYPE ■ Grab ⧅ No Recov ☒ SPT ▤ Other ◫ Tube ⊠ Core

DEPTH (m)	SOIL DESCRIPTION
0	TOPSOIL,organic,fibrous,black brown,silty, roots,frozen
	SAND,very dense,fine grained,pink brown, damp,poorly graded
	frozen to 1.6 m
	BEDROCK,granite
4	End of Hole at 3.9 m (Auger Refusal) Hole dry at completion No sloughing



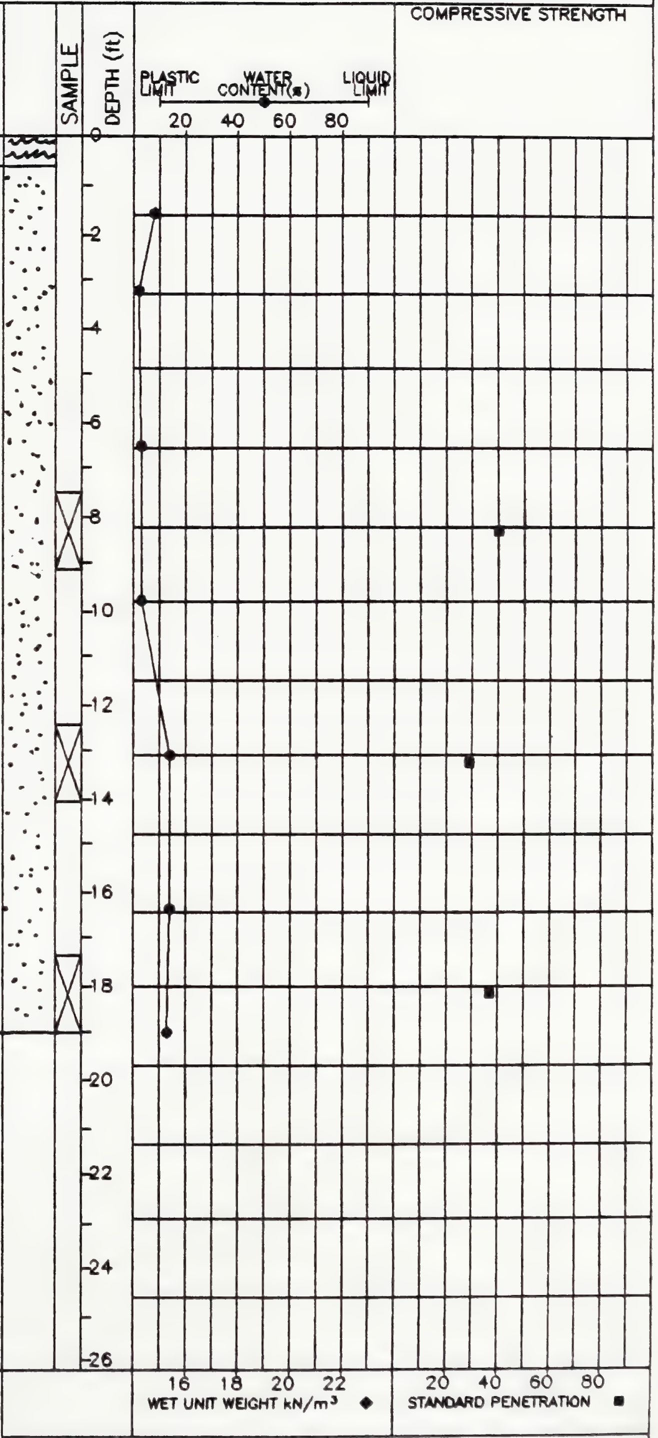
COMPLETION DEPTH 3.9 m	COMPLETE 88/03/12
LOGGED BY RBS	DWG No.

Hardy BBT Limited
Edmonton Alberta

ALBERTA MUNICIPAL AFFAIRS	BOREHOLE No. 2	EG06558
SUBDIVISION DEVELOPMENT FORT CHIPEWYAN, ALBERTA	RELATIVE ELEVATION 98.6 (m) TRUCK B61, SOLID STEM AUGER	

SAMPLE TYPE ■ Grab ⧄ No Recov ☒ SPT ▤ Other ◫ Tube ▣ Core

DEPTH (m)	SOIL DESCRIPTION
0	TOPSOIL,organic,fibrous,black–brown,silty, roots,frozen
	SAND,poorly graded,light pink–brown,very dense,fine grained,trace of silt,gravel sizes to 25 mm
1	
	frozen to 1.8 m
2	
	fine to medium grained,uniform,light peach color,damp,occasional small pebble SO4=0.01%
3	
4	
	damp to moist
5	more gravelly
	SO4=0.01%
	End of Hole at 5.8 m Hole dry at completion No sloughing
6	
7	
8	



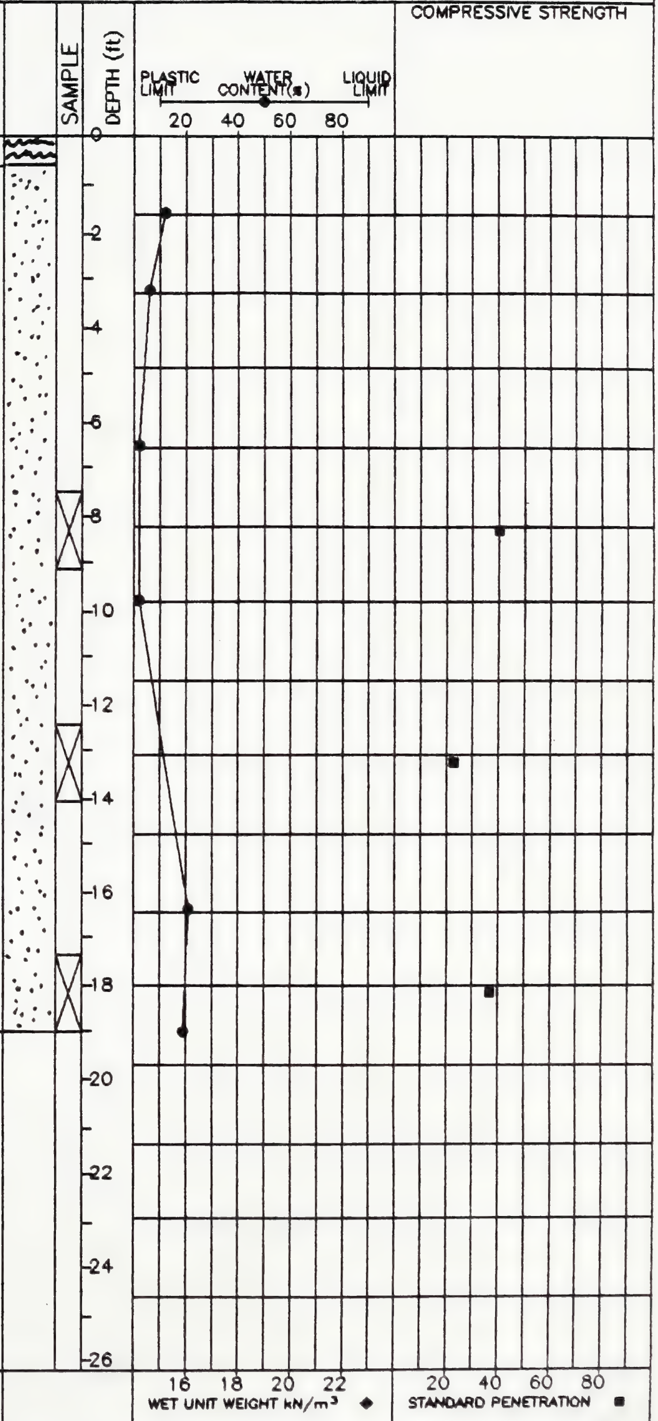
COMPLETION DEPTH 3.9 m	COMPLETE 88/03/12
LOGGED BY RBS	DWG No.

Hardy BBT Limited
Edmonton Alberta

ALBERTA MUNICIPAL AFFAIRS	BOREHOLE No. 3	EG06558
SUBDIVISION DEVELOPMENT FORT CHIPEWYAN, ALBERTA	RELATIVE ELEVATION 98.1 (m) TRUCK B61, SOLID STEM AUGER	

SAMPLE TYPE ■ Grab ⧅ No Recov ☒ SPT ▤ Other ▥ Tube ▣ Core

DEPTH (m)	SOIL DESCRIPTION
0	TOPSOIL,organic,fibrous,black-brown,silty, roots,frozen
	SAND,silty,brown-light pink,fine grained
1	
2	frozen to 1.8 m light pink-brown,poorly graded,damp,very dense,fine grained,trace of silt SO4=0.01%
3	
4	damp to moist,fine to medium grained, rusty peach color,uniform,occasional small black specks
5	
6	End of Hole at 5.8 m Hole dry at completion No sloughing
7	
8	

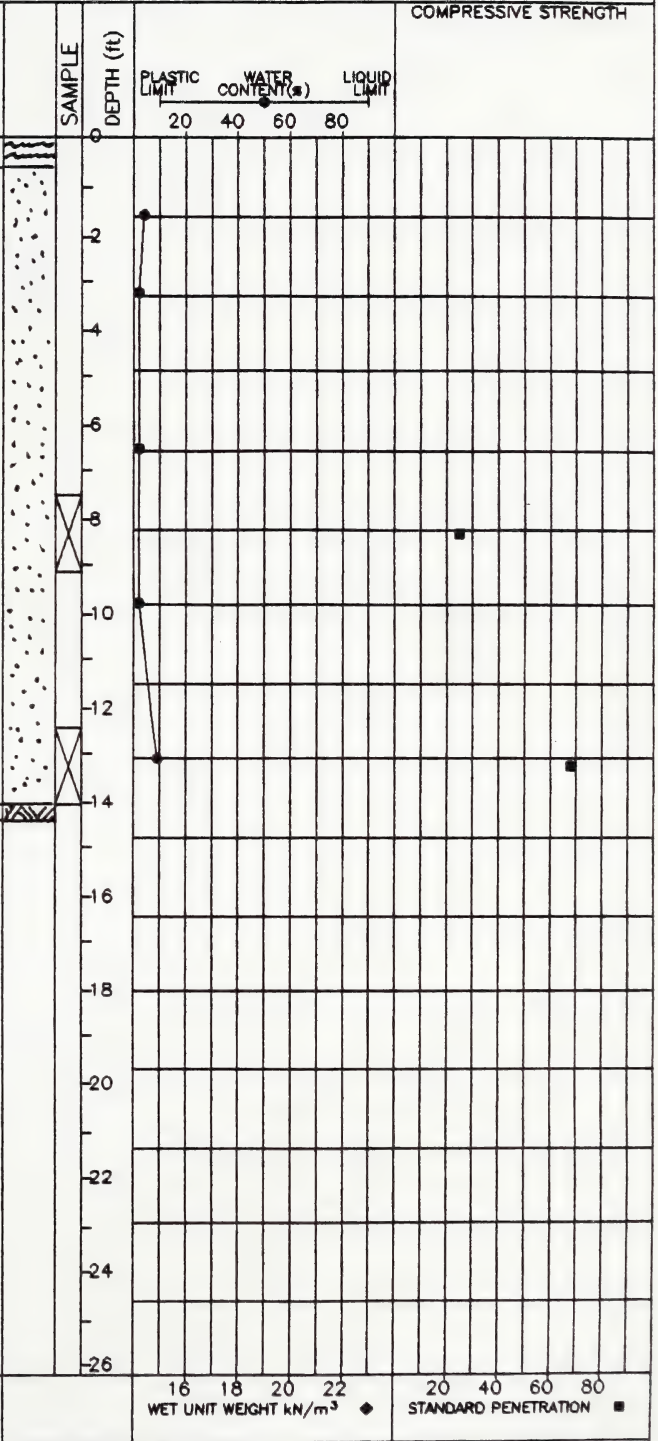


Hardy BBT Limited Edmonton Alberta	COMPLETION DEPTH 5.8 m	COMPLETE 88/03/12
	LOGGED BY RBS	DWG No.

ALBERTA MUNICIPAL AFFAIRS	BOREHOLE No. 4	EG06558
SUBDIVISION DEVELOPMENT FORT CHIPEWYAN, ALBERTA	RELATIVE ELEVATION 98.5 (m) TRUCK B61, SOLID STEM AUGER	

SAMPLE TYPE ■ Grab ⧄ No Recov ☒ SPT ▤ Other ▥ Tube ⧗ Core

DEPTH (m)	SOIL DESCRIPTION
0	TOPSOIL,organic,fibrous,,black–brown,silty frozen SAND,poorly graded,trace of silt,damp, dense,fine grained,light pink–brown
1	
2	
3	
4	trace of moisture SO4=0.01%
	BEDROCK,granite End of Hole at 4.4 m (Auger Refusal) Hole dry at completion No sloughing
5	
6	
7	
8	



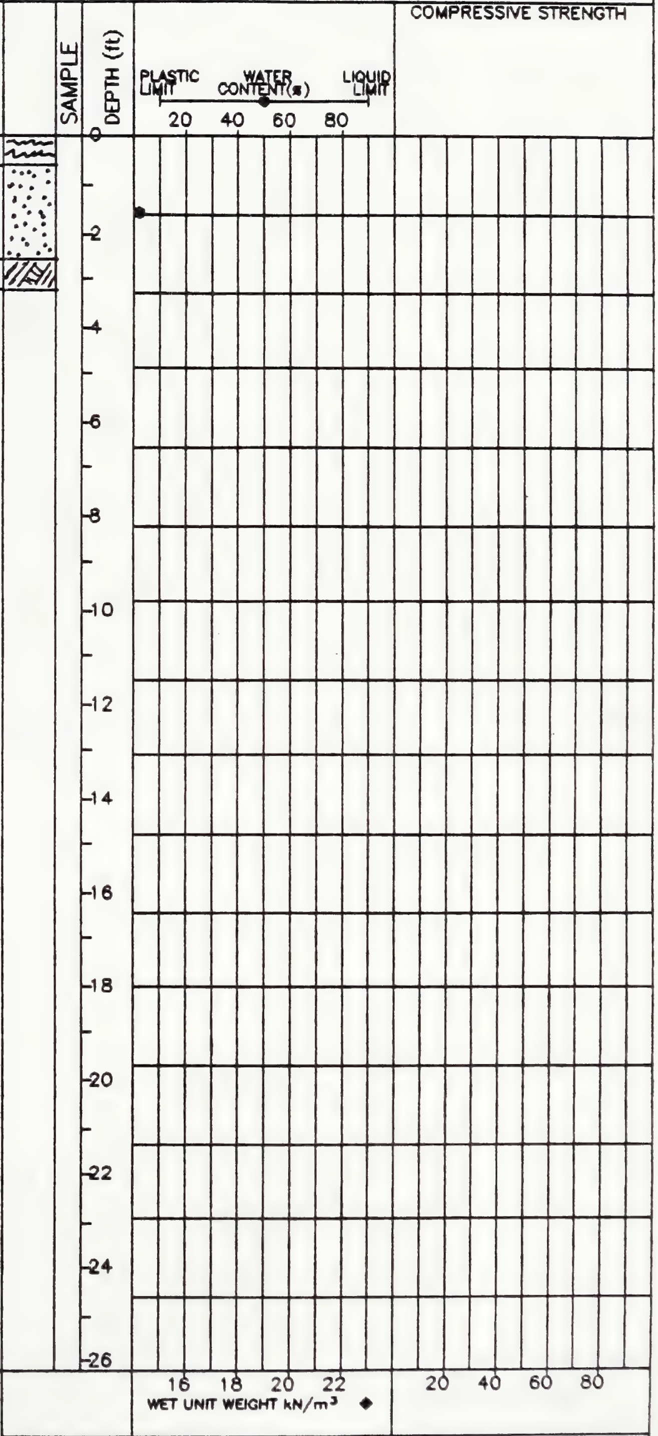
COMPLETION DEPTH 4.4 m	COMPLETE 88/03/12
LOGGED BY RBS	DWG No.

Hardy BBT Limited
Edmonton Alberta

ALBERTA MUNICIPAL AFFAIRS	BOREHOLE No. 5	EG06558
SUBDIVISION DEVELOPMENT FORT CHIPEWYAN, ALBERTA	RELATIVE ELEVATION 101.2 (m) TRUCK B61, SOLID STEM AUGER	

SAMPLE TYPE ■ Grab ⧄ No Recov ☒ SPT ▤ Other ▥ Tube ▧ Core

DEPTH (m)	SOIL DESCRIPTION
0	TOPSOIL,organics,fibrous,brown–black,roots
	SAND,poorly graded,light brown
	BEDROCK,granite
1	End of Hole 1.0 m (Auger Refusal) Hole dry at completion
2	
3	
4	
5	
6	
7	
8	

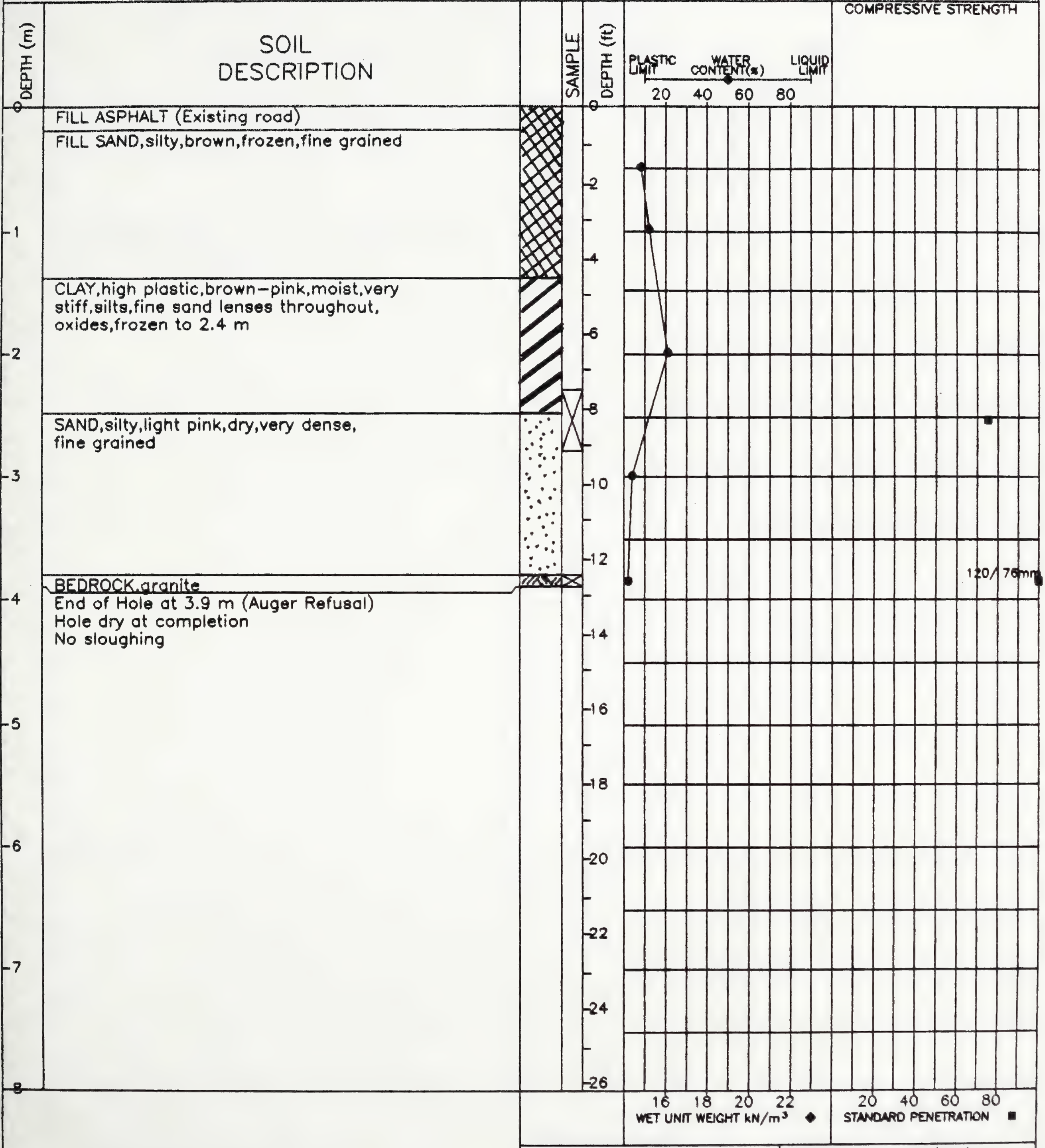


COMPLETION DEPTH .9 m	COMPLETE 88/03/12
LOGGED BY RBS	DWG No.

Hardy BBT Limited
Edmonton Alberta

ALBERTA MUNICIPAL AFFAIRS	BOREHOLE No. 6	EG06558
SUBDIVISION DEVELOPMENT FORT CHIPEWYAN, ALBERTA	RELATIVE ELEVATION 98.4 (m) TRUCK B61, SOLID STEM AUGER	

SAMPLE TYPE ■ Grab ⧅ No Recov ☒ SPT ▤ Other ▥ Tube ▥ Core



SOIL DESCRIPTION

FILL ASPHALT (Existing road)

FILL SAND,silty,brown,frozen,fine grained

CLAY,high plastic,brown–pink,moist,very stiff,silts,fine sand lenses throughout, oxides,frozen to 2.4 m

SAND,silty,light pink,dry,very dense, fine grained

BEDROCK,granite

End of Hole at 3.9 m (Auger Refusal)
Hole dry at completion
No sloughing

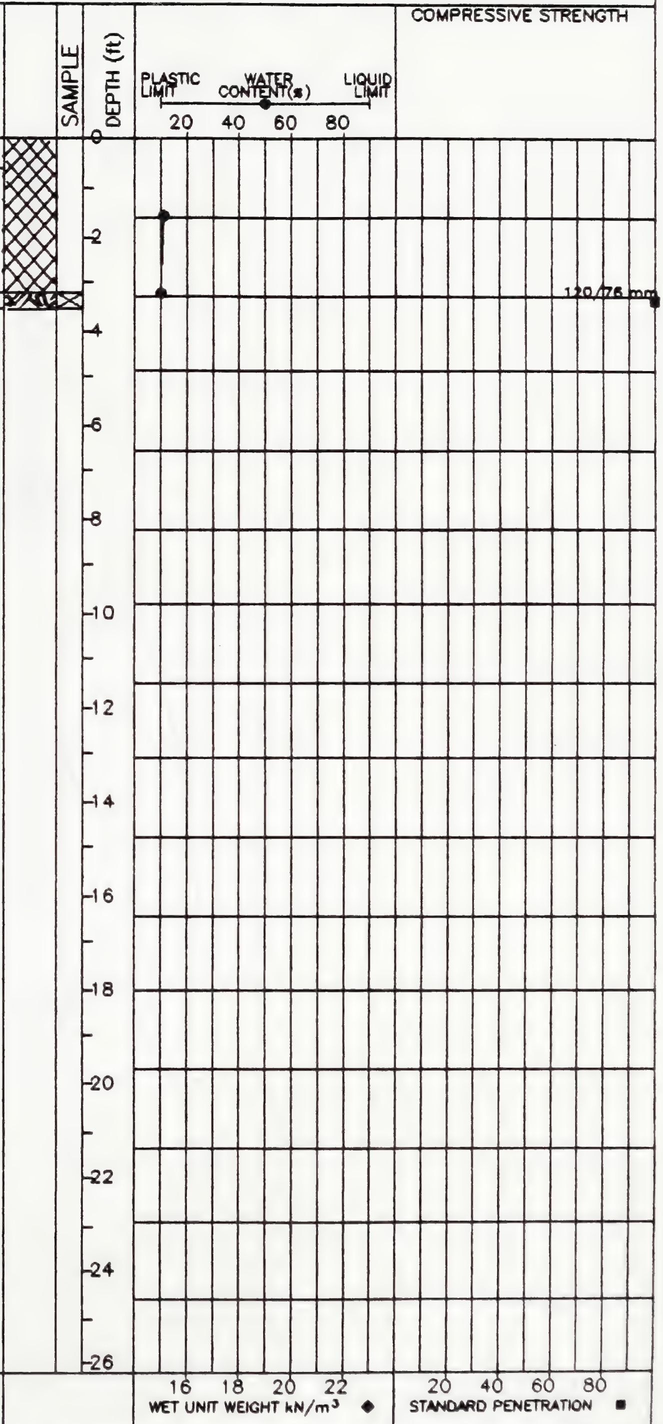
COMPLETION DEPTH 3.9 m	COMPLETE 88/02/12
LOGGED BY RBS	DWG No.

Hardy BBT Limited
Edmonton Alberta

ALBERTA MUNICIPAL AFFAIRS	BOREHOLE No. 7
SUBDIVISION DEVELOPMENT FORT CHIPEWYAN, ALBERTA	RELATIVE ELEVATION 99.9 (m) TRUCK B61, SOLID STEM AUGER

SAMPLE TYPE ■ Grab ⧄ No Recov ☒ SPT ▤ Other ▥ Tube ▥ Core

DEPTH (m)	SOIL DESCRIPTION
0	FILL ASPHALT (Existing Road)
	FILL SAND,silty,brown,frozen,fine grained, wood chips throughout
1	BEDROCK,granite
	End of Hole at 1.1 m (Auger Refusal) Hole dry at completion No sloughing
2	
3	
4	
5	
6	
7	
8	



COMPLETION DEPTH 1.1 m	COMPLETE 88/03/12
LOGGED BY RBS	DWG No.

Hardy BBT Limited
Edmonton Alberta

ALBERTA MUNICIPAL AFFAIRS	BOREHOLE No. 8	EG06558
SUBDIVISION DEVELOPMENT FORT CHIPEWYAN, ALBERTA	RELATIVE ELEVATION 100.6 (m) TRUCK B61, SOLID STEM AUGER	

SAMPLE TYPE ■ Grab ⍂ No Recov ☒ SPT ▤ Other ▥ Tube ▣ Core

SOIL DESCRIPTION

FILL ASPHALT (Existing Road)

FILL SAND, silty, brown, frozen, fine grained, odd small gravel to 10 mm

CLAY, high plastic, silty, oxides, frozen

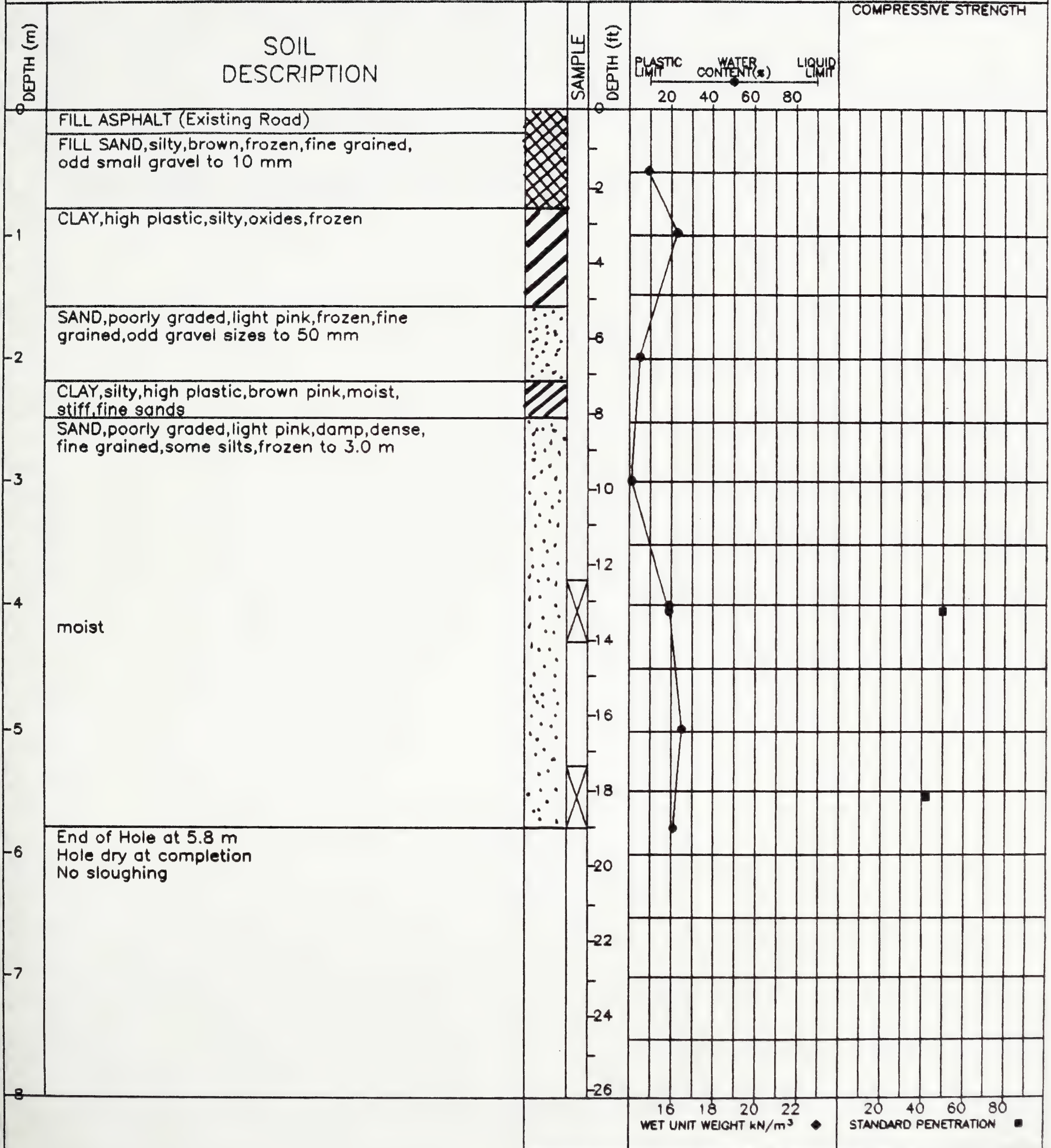
SAND, poorly graded, light pink, frozen, fine grained, odd gravel sizes to 50 mm

CLAY, silty, high plastic, brown pink, moist, stiff, fine sands

SAND, poorly graded, light pink, damp, dense, fine grained, some silts, frozen to 3.0 m

moist

End of Hole at 5.8 m
Hole dry at completion
No sloughing



COMPLETION DEPTH 5.8 m	COMPLETE 88/03/12
LOGGED BY RBS	DWG No.

Hardy BBT Limited
Edmonton Alberta

ALBERTA MUNICIPAL AFFAIRS	BOREHOLE No. 9	EG06558
SUBDIVISION DEVELOPMENT FORT CHIPEWYAN, ALBERTA	RELATIVE ELEVATION 94.4 (m) TRUCK B61, SOLID STEM AUGER	

SAMPLE TYPE ■ Grab ⧅ No Recov ☒ SPT ▤ Other ▥ Tube ▩ Core

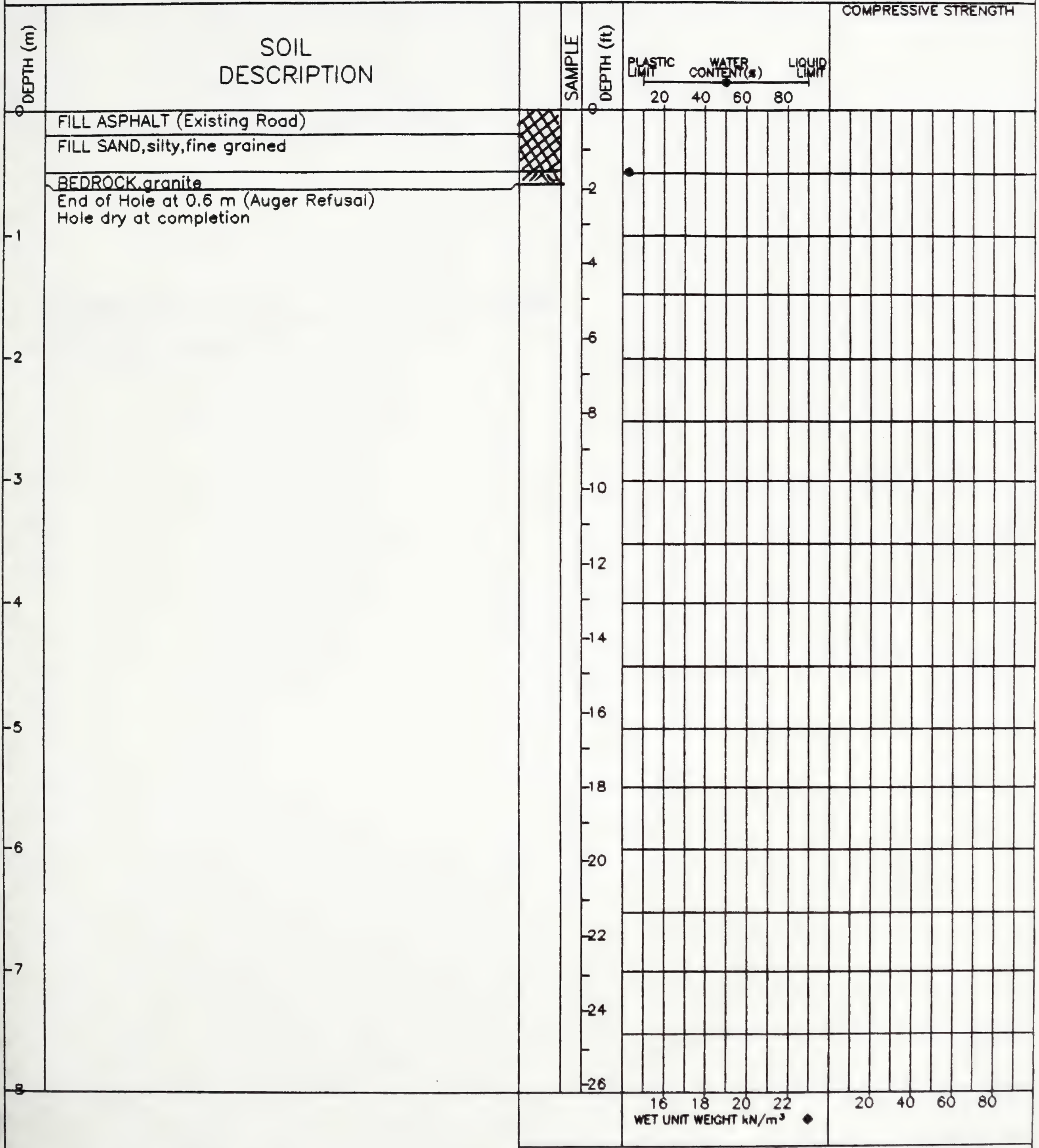
SOIL DESCRIPTION

FILL ASPHALT (Existing Road)

FILL SAND,silty,fine grained

BEDROCK,granite

End of Hole at 0.6 m (Auger Refusal)
Hole dry at completion

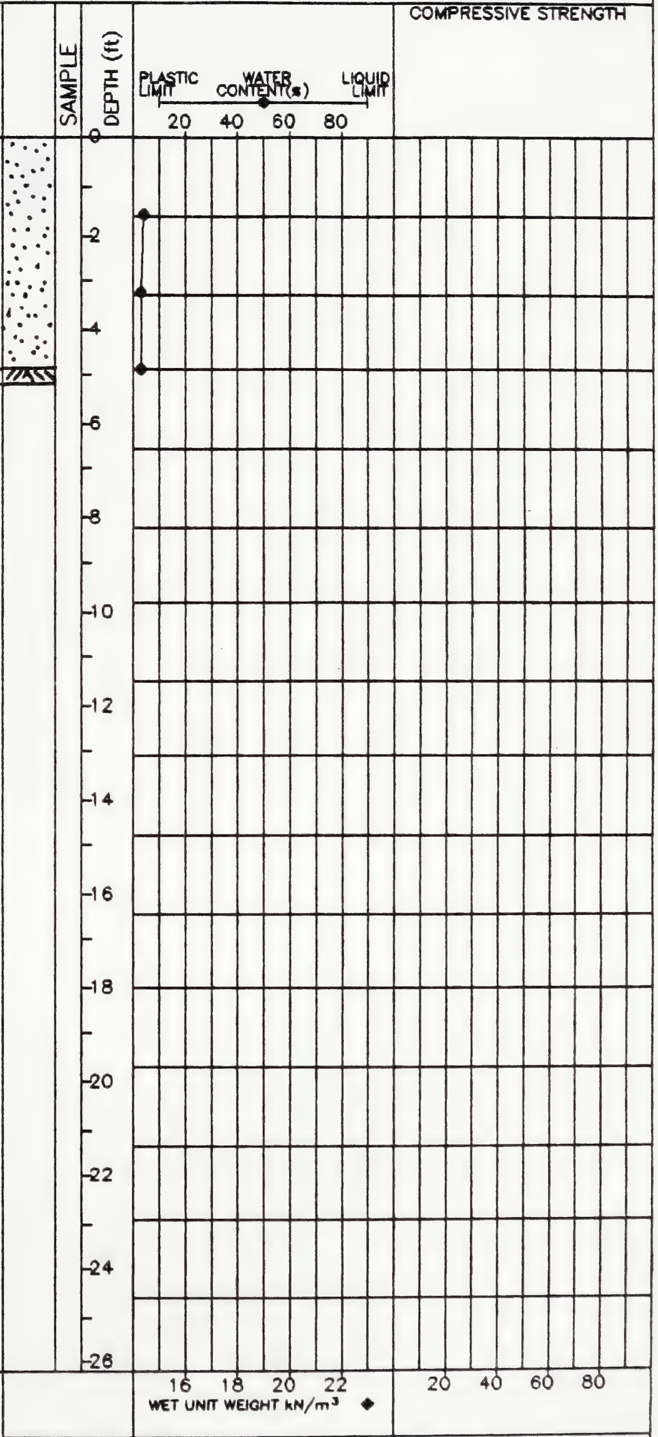


Hardy BBT Limited Edmonton Alberta	COMPLETION DEPTH .6 m	COMPLETE 88/03/12
	LOGGED BY RBS	DWG No.

ALBERTA MUNICIPAL AFFAIRS	BOREHOLE No. 10	EG06558
SUBDIVISION DEVELOPMENT FORT CHIPEWYAN, ALBERTA	RELATIVE ELEVATION 105.5 (m) TRUCK B61, SOLID STEM AUGER	

SAMPLE TYPE ■ Grab ◺ No Recov ☒ SPT ▤ Other ▥ Tube ▮ Core

DEPTH (m)	SOIL DESCRIPTION
0	SAND, poorly graded, light brown-pink, fine grained, gravelly, frozen
1.5	BEDROCK, granite
	End of Hole at 1.6 m (Auger Refusal) Hole dry at completion No sloughing

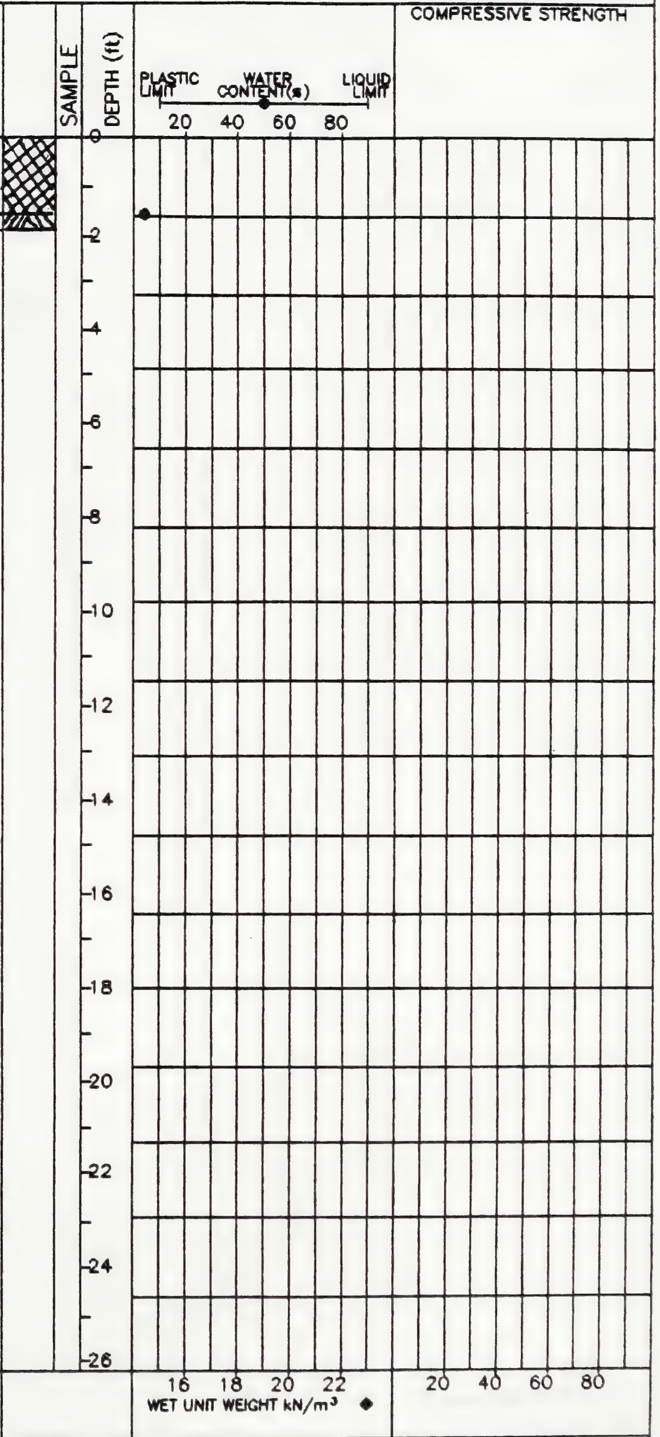


Hardy BBT Limited Edmonton Alberta	COMPLETION DEPTH 1.6 m	COMPLETE 88/03/12
	LOGGED BY RBS	DWG No.

ALBERTA MUNICIPAL AFFAIRS	BOREHOLE No. 11	EG06558
SUBDIVISION DEVELOPMENT FORT CHIPEWYAN, ALBERTA	RELATIVE ELEVATION 109.8 (m) TRUCK B61, SOLID STEM AUGER	

SAMPLE TYPE ■ Grab ⧄ No Recov ☒ SPT ▤ Other ▥ Tube ▨ Core

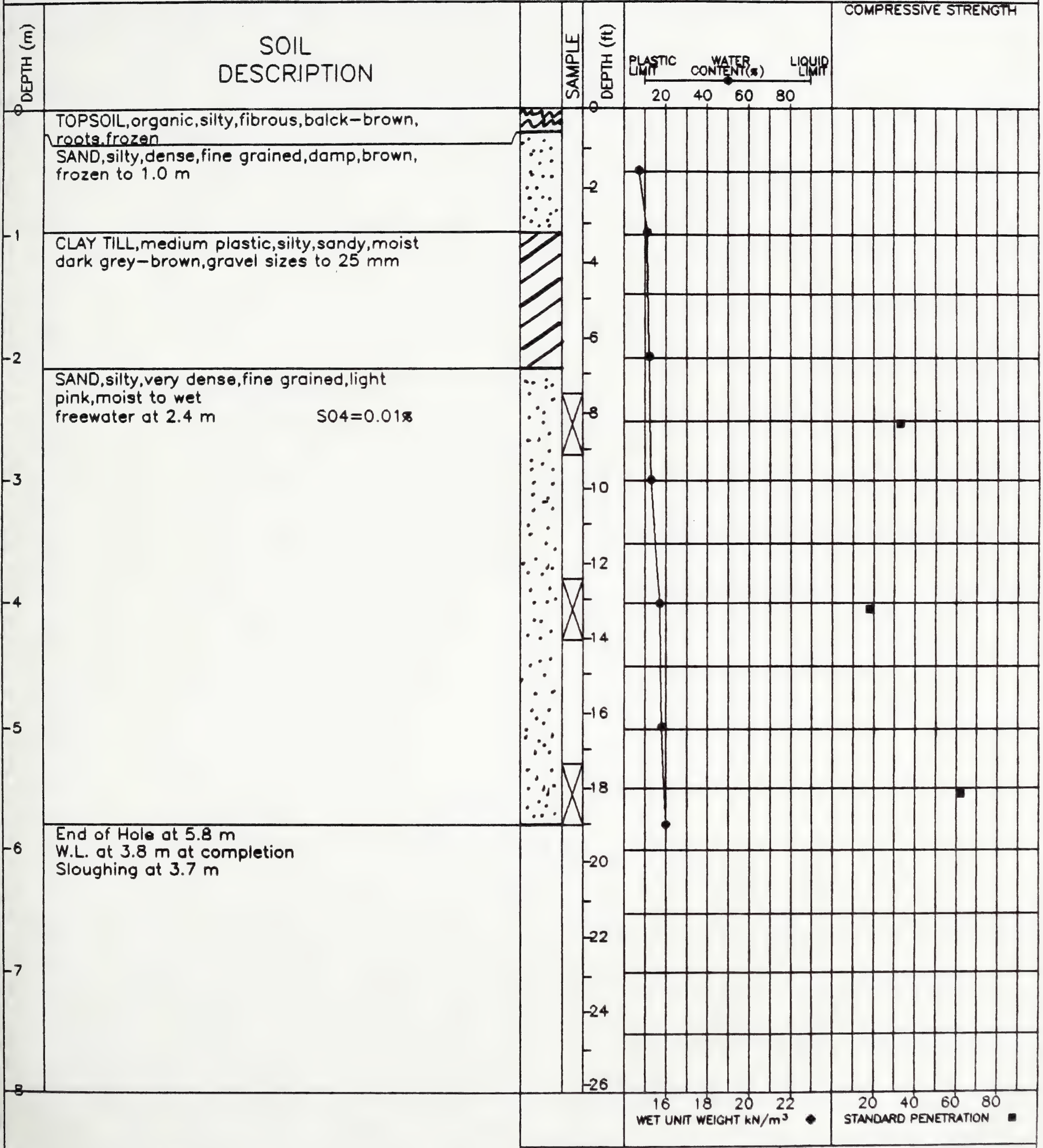
DEPTH (m)	SOIL DESCRIPTION
0	FILL SAND, silty, fine grained, brown, frozen
	BEDROCK, granite
	End of Hole at 0.6 m (Auger Refusal) Hole dry at completion
1	NOTE: Tried 7 different locations but was unable to penetrate any deeper.
2	
3	
4	
5	
6	
7	
8	



Hardy BBT Limited Edmonton Alberta	COMPLETION DEPTH .6 m	COMPLETE 88/03/12
	LOGGED BY RBS	DWG No.

ALBERTA MUNICIPAL AFFAIRS	BOREHOLE No. 12	EG06558
SUBDIVISION DEVELOPMENT FORT CHIPEWYAN, ALBERTA	RELATIVE ELEVATION 107.5 (m) TRUCK B61, SOLID STEM AUGER	

SAMPLE TYPE ■ Grab ⍂ No Recov ☒ SPT ☰ Other ▥ Tube Core



SOIL DESCRIPTION

TOPSOIL,organic,silty,fibrous,balck-brown, roots,frozen

SAND,silty,dense,fine grained,damp,brown, frozen to 1.0 m

CLAY TILL,medium plastic,silty,sandy,moist dark grey-brown,gravel sizes to 25 mm

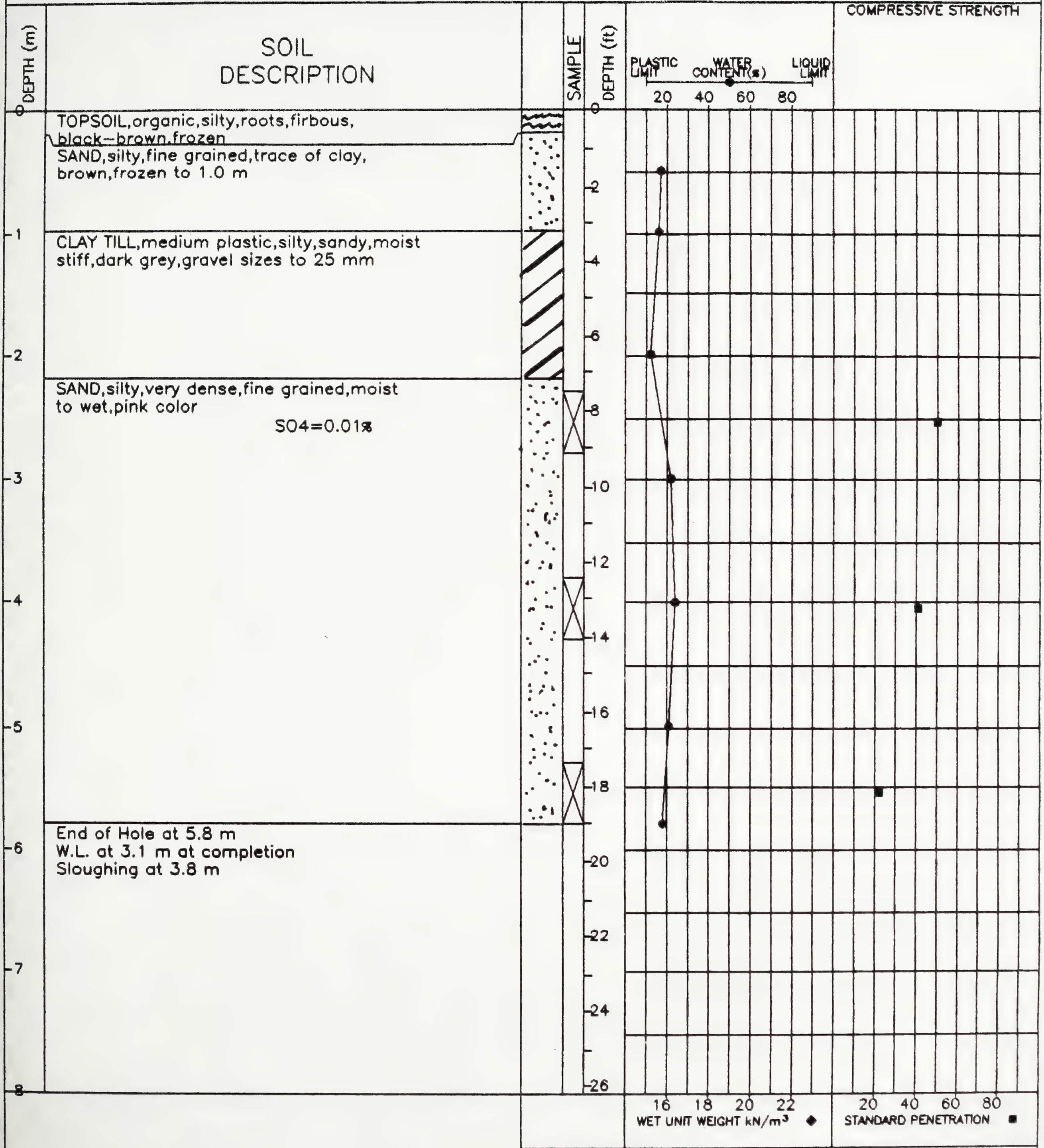
SAND,silty,very dense,fine grained,light pink,moist to wet
freewater at 2.4 m S04=0.01%

End of Hole at 5.8 m
W.L. at 3.8 m at completion
Sloughing at 3.7 m

Hardy BBT Limited Edmonton Alberta	COMPLETION DEPTH 5.8 m	COMPLETE 88/03/13
	LOGGED BY RBS	DWG No.

ALBERTA MUNICIPAL AFFAIRS	BOREHOLE No. 13	EG06558
SUBDIVISION DEVELOPMENT FORT CHIPEWYAN, ALBERTA	RELATIVE ELEVATION 107.6 (m) TRUCK B61, SOLID STEM AUGER	

SAMPLE TYPE ■ Grab ⧄ No Recov ☒ SPT ▤ Other ▥ Tube ☒ Core



SOIL DESCRIPTION

TOPSOIL,organic,silty,roots,firbous, black–brown,frozen

SAND,silty,fine grained,trace of clay, brown,frozen to 1.0 m

CLAY TILL,medium plastic,silty,sandy,moist stiff,dark grey,gravel sizes to 25 mm

SAND,silty,very dense,fine grained,moist to wet,pink color

SO4=0.01%

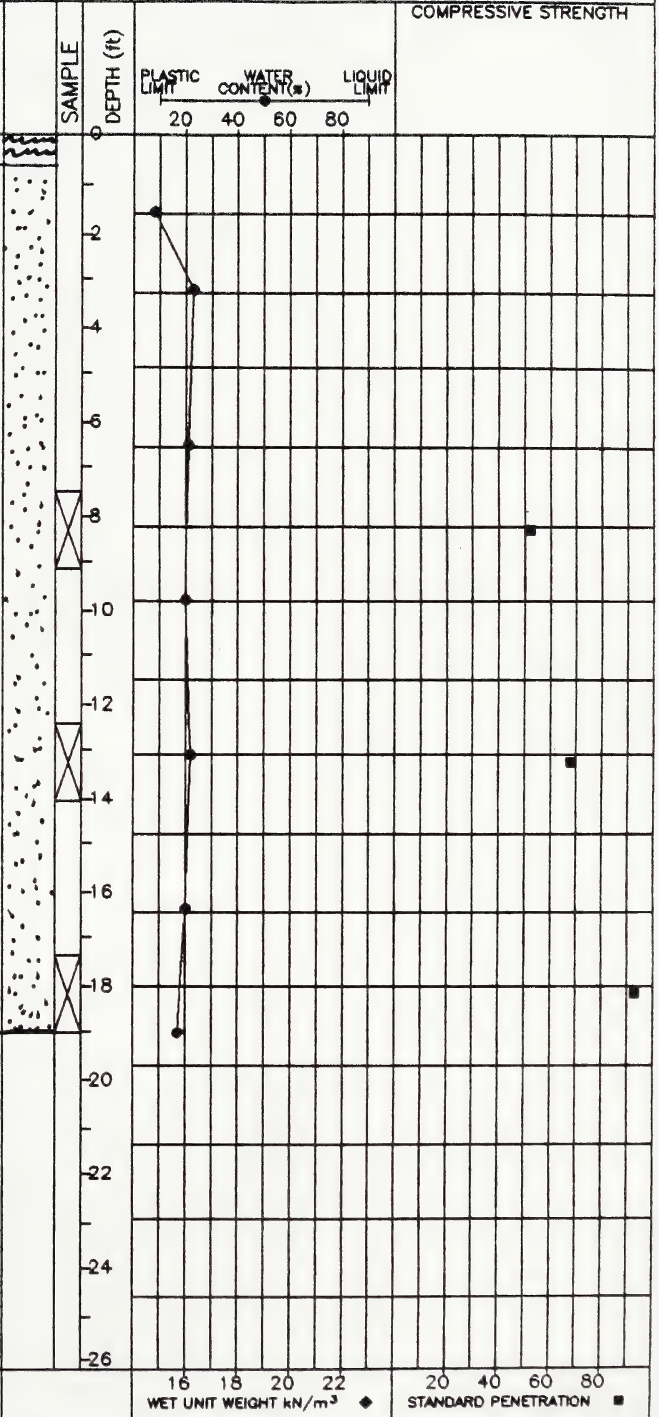
End of Hole at 5.8 m
W.L. at 3.1 m at completion
Sloughing at 3.8 m

Hardy BBT Limited Edmonton Alberta	COMPLETION DEPTH 5.8 m	COMPLETE 88/03/13
	LOGGED BY RBS	DWG No.

ALBERTA MUNICIPAL AFFAIRS	BOREHOLE No. 14	EG06558
SUBDIVISION DEVELOPMENT FORT CHIPEWYAN, ALBERTA	RELATIVE ELEVATION 107.7 (m) TRUCK B61, SOLID STEM AUGER	

SAMPLE TYPE ■ Grab ⧄ No Recov ☒ SPT ▤ Other ▥ Tube ⌧ Core

DEPTH (m)	SOIL DESCRIPTION
0	TOPSOIL,organic,fibrous,black–brown,frozen
	SAND,silty,dense,fine grained,light pink, frozen to 0.8 m
1	
2	moist to wet,sloughing,very dense
	SO4=0.01%
3	
4	
5	
	End of Hole at 5.8 m W.L. at 3.5 m at completion Sloughing at 4.2 m
6	
7	
8	

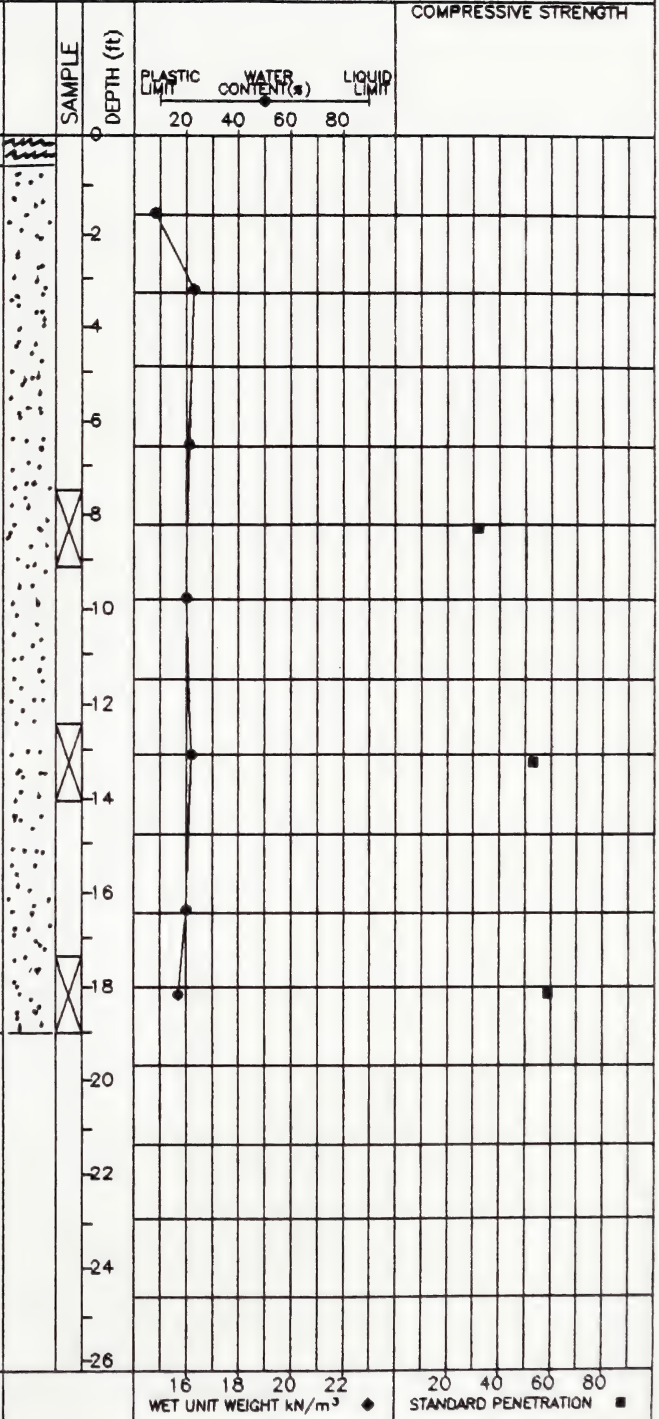


Hardy BBT Limited Edmonton Alberta	COMPLETION DEPTH 5.8 m	COMPLETE 88/03/13
	LOGGED BY RBS	DWG No.

ALBERTA MUNICIPAL AFFAIRS	BOREHOLE No. 15	EG06558
SUBDIVISION DEVELOPMENT FORT CHIPEWYAN, ALBERTA	RELATIVE ELEVATION 107.7 (m) TRUCK B61, SOLID STEM AUGER	

SAMPLE TYPE ■ Grab ⧅ No Recov ☒ SPT ▤ Other ▥ Tube ⊠ Core

DEPTH (m)	SOIL DESCRIPTION
0	TOPSOIL,organic,silty,fibrous,black–brown, roots,frozen
	SAND,silty,very dense,fine grained,light pink color,frozen to 0.8 m,odd gravel size to 25 mm,moist to wet SO4=0.01%
1	
2	
3	
4	
5	large rocks or boulders,broke lead auger and rock bit,moved hole 2 m
6	End of Hole at 5.8 m W.L. at 3.5 m at completion Sloughed in at 3.8 m
7	
8	



Hardy BBT Limited Edmonton Alberta	COMPLETION DEPTH 5.8 m	COMPLETE 88/03/13
	LOGGED BY RBS	DWG No.

ALBERTA MUNICIPAL AFFAIRS	BOREHOLE No. 16	EG06558
SUBDIVISION DEVELOPMENT FORT CHIPEWYAN, ALBERTA	RELATIVE ELEVATION 96 (m) TRUCK B61, SOLID STEM AUGER	

SAMPLE TYPE ■ Grab ⧄ No Recov ☒ SPT ▤ Other ▥ Tube Core

DEPTH (m)

SOIL DESCRIPTION

FILL ASPHALT (Existing Road)

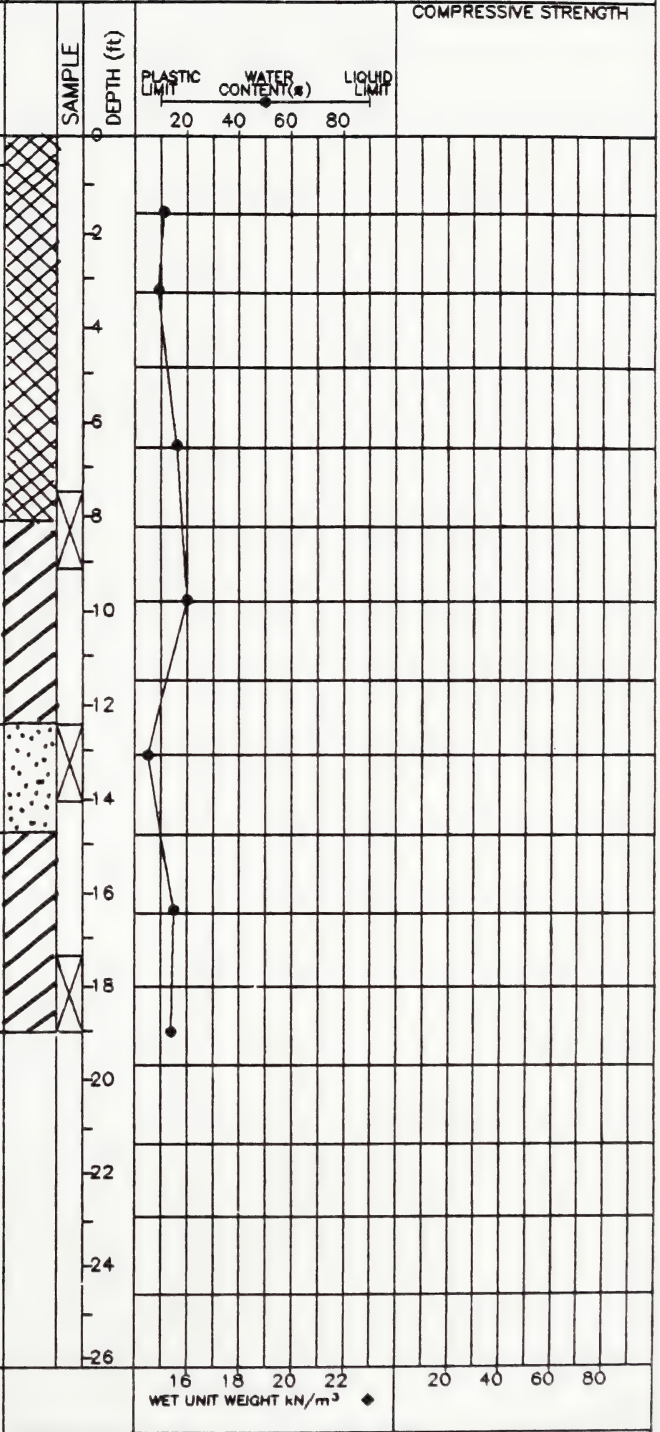
FILL SAND,silty,fine grained,brown,frozen

CLAY,silty,stiff,fine sands,moist,brown
frozen to 2.8 m

SAND,silty,dense,fine grained,damp,brown
SO4=0.01%

CLAY,high plastic,stiff,silty,sand lenses
throughout,pink brown

End of Hole at 5.8 m
Hole dry at completion
No sloughing



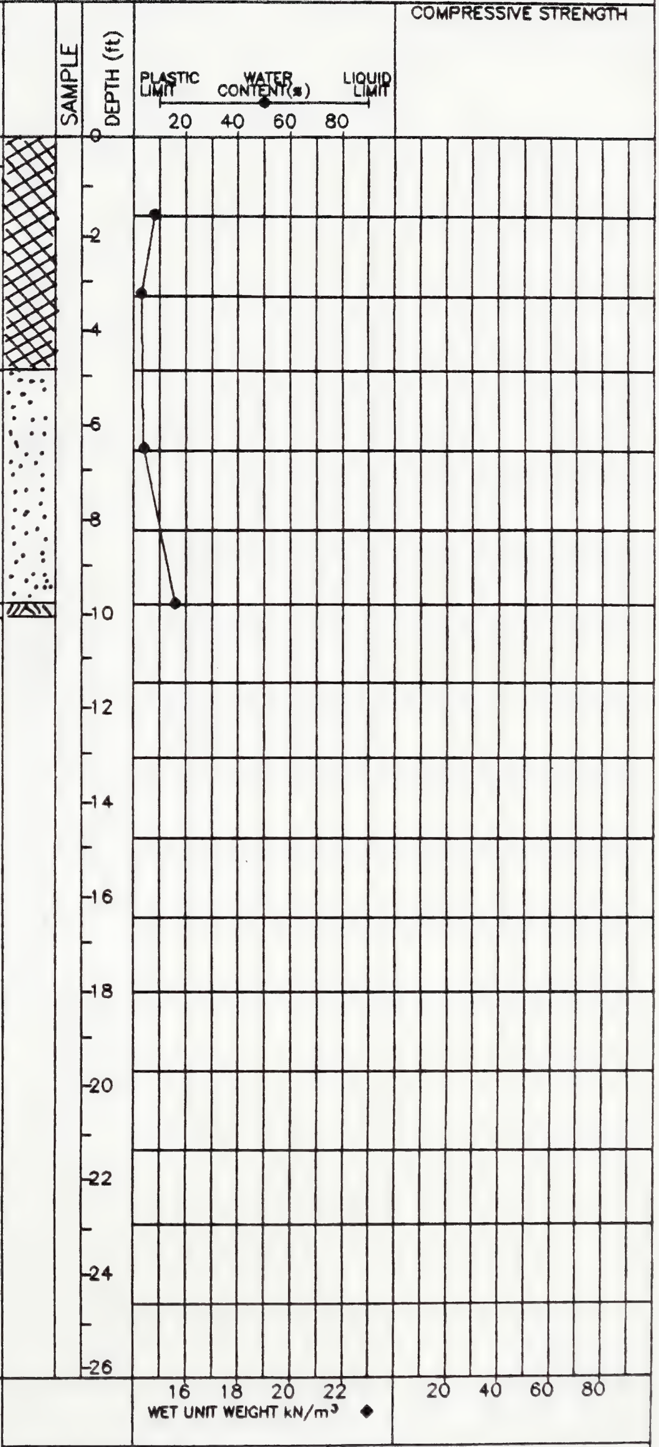
Hardy BBT Limited
Edmonton Alberta

COMPLETION DEPTH 5.8 m	COMPLETE 88/03/12
LOGGED BY RBS	DWG No.

ALBERTA MUNICIPAL AFFAIRS	BOREHOLE No. 17	EG06558
SUBDIVISION DEVELOPMENT FORT CHIPEWYAN, ALBERTA	RELATIVE ELEVATION 100.2 (m) TRUCK B61, SOLID STEM AUGER	

SAMPLE TYPE ■ Grab ◺ No Recov ☒ SPT ▤ Other ▥ Tube ▯ Core

DEPTH (m)	SOIL DESCRIPTION
0	FILL ASPHALT (Existing Road)
	FILL SAND,silty,fine grained,brown,frozen
1	
	SAND,poorly graded,fine grained,dense, light pink color,frozen to 2.5 m
2	
3	BEDROCK,granite
	End of Hole at 3.1 m (Auger Refusal) Hole dry at completion No sloughing
4	
5	
6	
7	
8	



COMPLETION DEPTH 3.1 m	COMPLETE 88/03/12
LOGGED BY RBS	DWG No.

Hardy BBT Limited
Edmonton Alberta

ALBERTA MUNICIPAL AFFAIRS	BOREHOLE No. 18 — EG06558
SUBDIVISION DEVELOPMENT FORT CHIPEWYAN, ALBERTA	RELATIVE ELEVATION 98.6 (m) TRUCK B61, SOLID STEM AUGER

SAMPLE TYPE ■ Grab ⧅ No Recov ☒ SPT ☰ Other ▥ Tube ▥ Core

SOIL DESCRIPTION

FILL ASPHALT (Existing Road)

FILL SAND,silty,fine grained,brown,frozen

SAND,silty,fine grained,light brown–pink

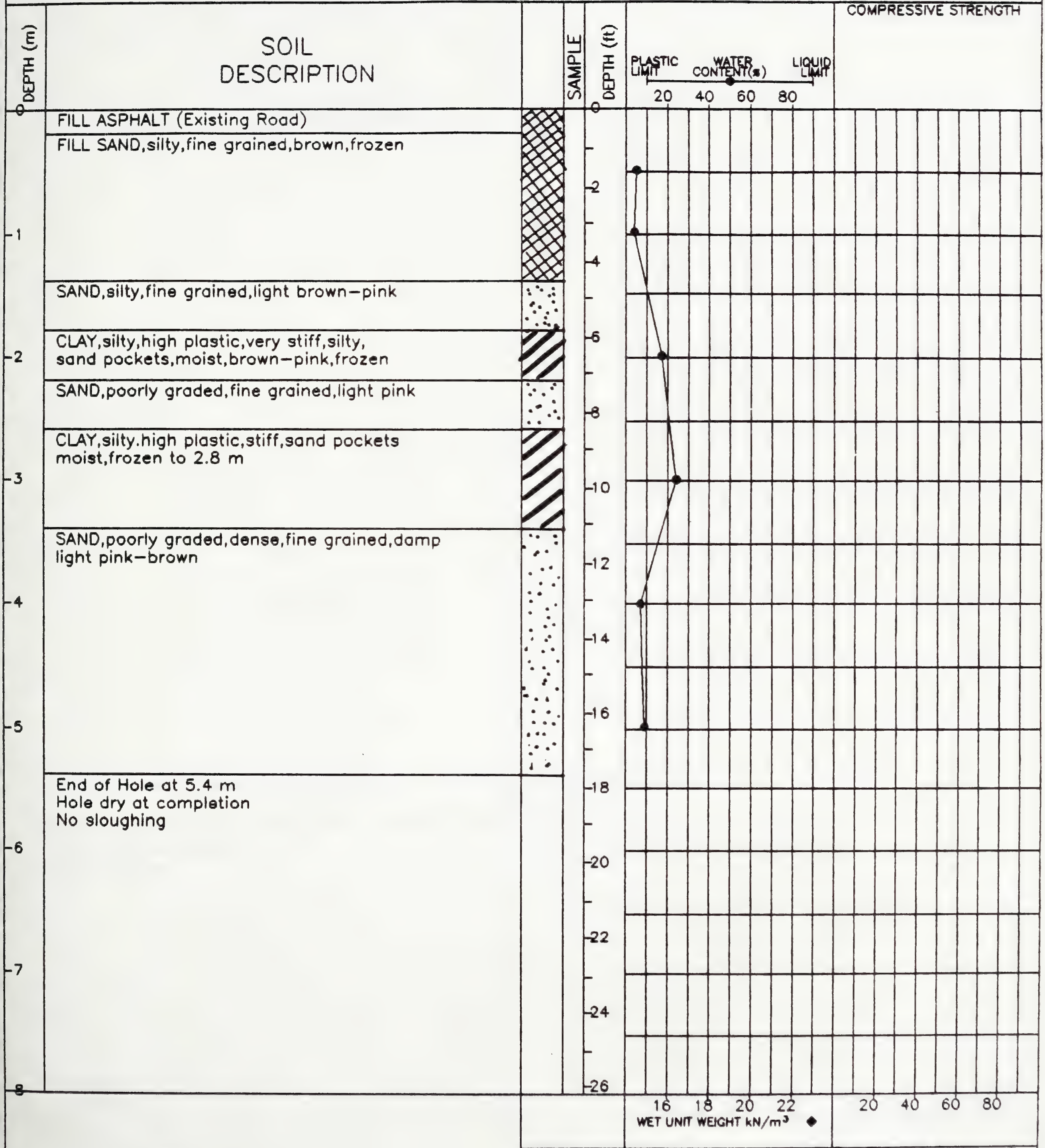
CLAY,silty,high plastic,very stiff,silty, sand pockets,moist,brown–pink,frozen

SAND,poorly graded,fine grained,light pink

CLAY,silty.high plastic,stiff,sand pockets moist,frozen to 2.8 m

SAND,poorly graded,dense,fine grained,damp light pink–brown

End of Hole at 5.4 m
Hole dry at completion
No sloughing



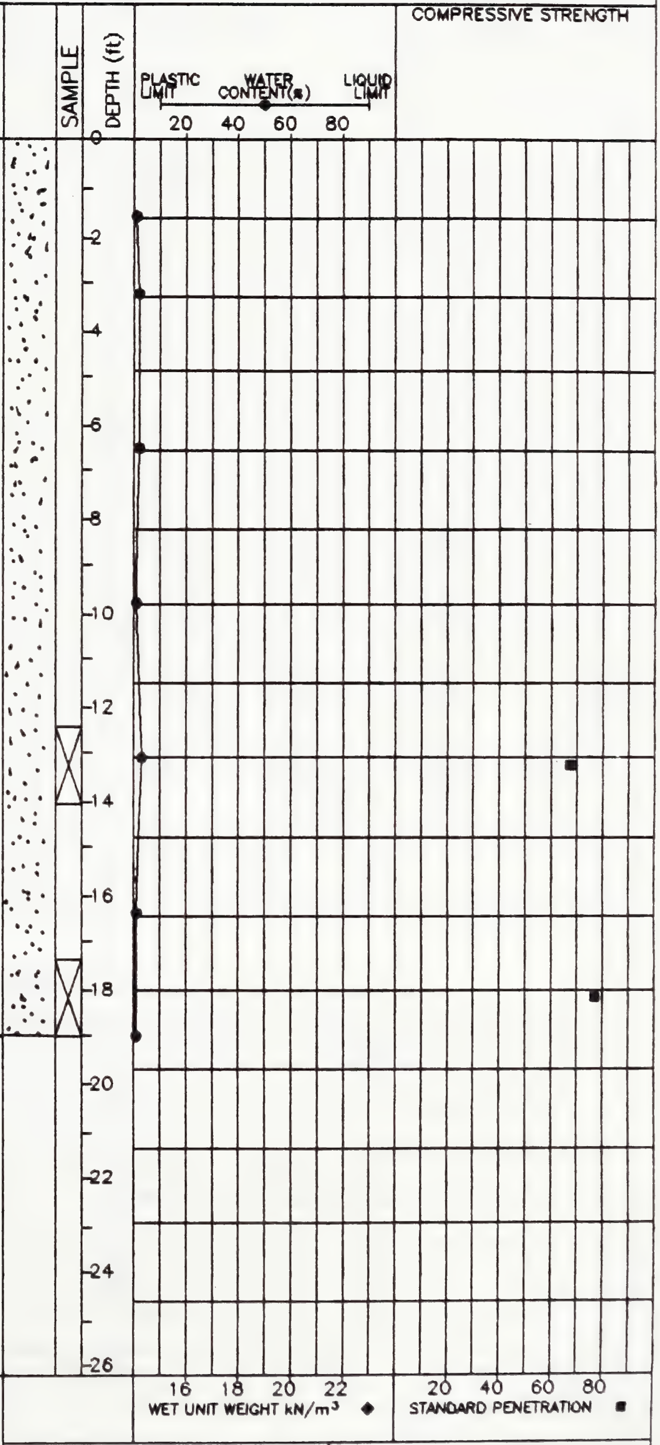
COMPLETION DEPTH 5.4 m	COMPLETE 88/03/12
LOGGED BY RBS	DWG No.

Hardy BBT Limited
Edmonton Alberta

ALBERTA MUNICIPAL AFFAIRS	BOREHOLE No. 19	EG06558
SUBDIVISION DEVELOPMENT FORT CHIPEWYAN, ALBERTA	RELATIVE ELEVATION 108.1 (m) TRUCK B61, SOLID STEM AUGER	

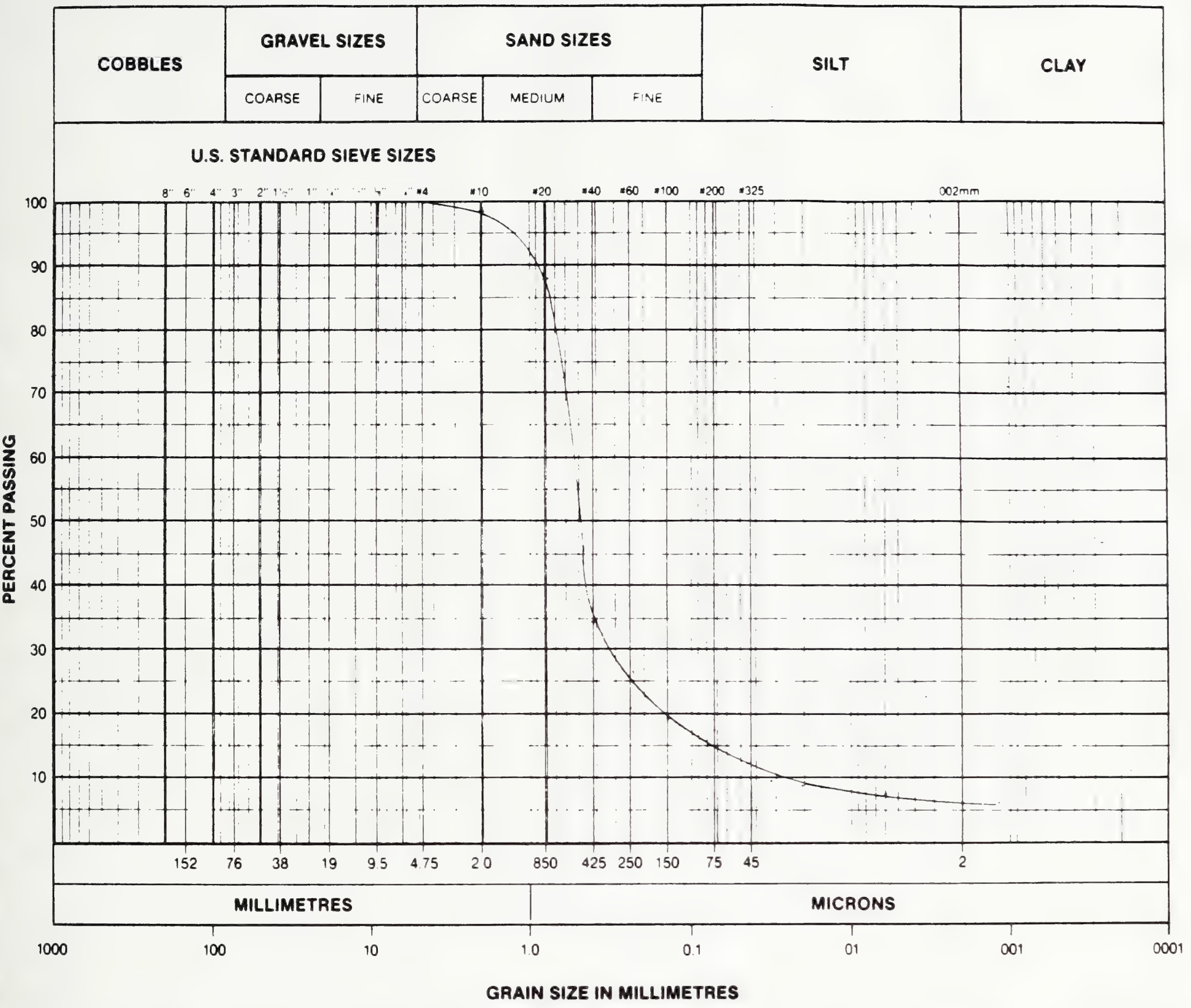
SAMPLE TYPE ■ Grab ⍁ No Recov ☒ SPT ▤ Other ▥ Tube ▥ Core

DEPTH (m)	SOIL DESCRIPTION
0	SAND,poorly graded,fine grained,very dense damp,light pink–brown,frozen to 2.5 m
1	
2	
3	
4	SO4=0.01%
5	medium grained,uniform,light peach color, damp,occasional small black specks
6	End of Hole at 5.8 m Hole dry at completion No sloughing
7	
8	



COMPLETION DEPTH 5.8 m	COMPLETE 88/03/12
LOGGED BY RBS	DWG No.

Hardy BBT Limited
Edmonton Alberta



REMARKS: ______

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY

D_{10} =	mm	GRAVEL		%
D_{30} =	mm	SAND		%
D_{60} =	mm	SILT		%
C_U =	mm	CLAY		%
C_C =	mm			

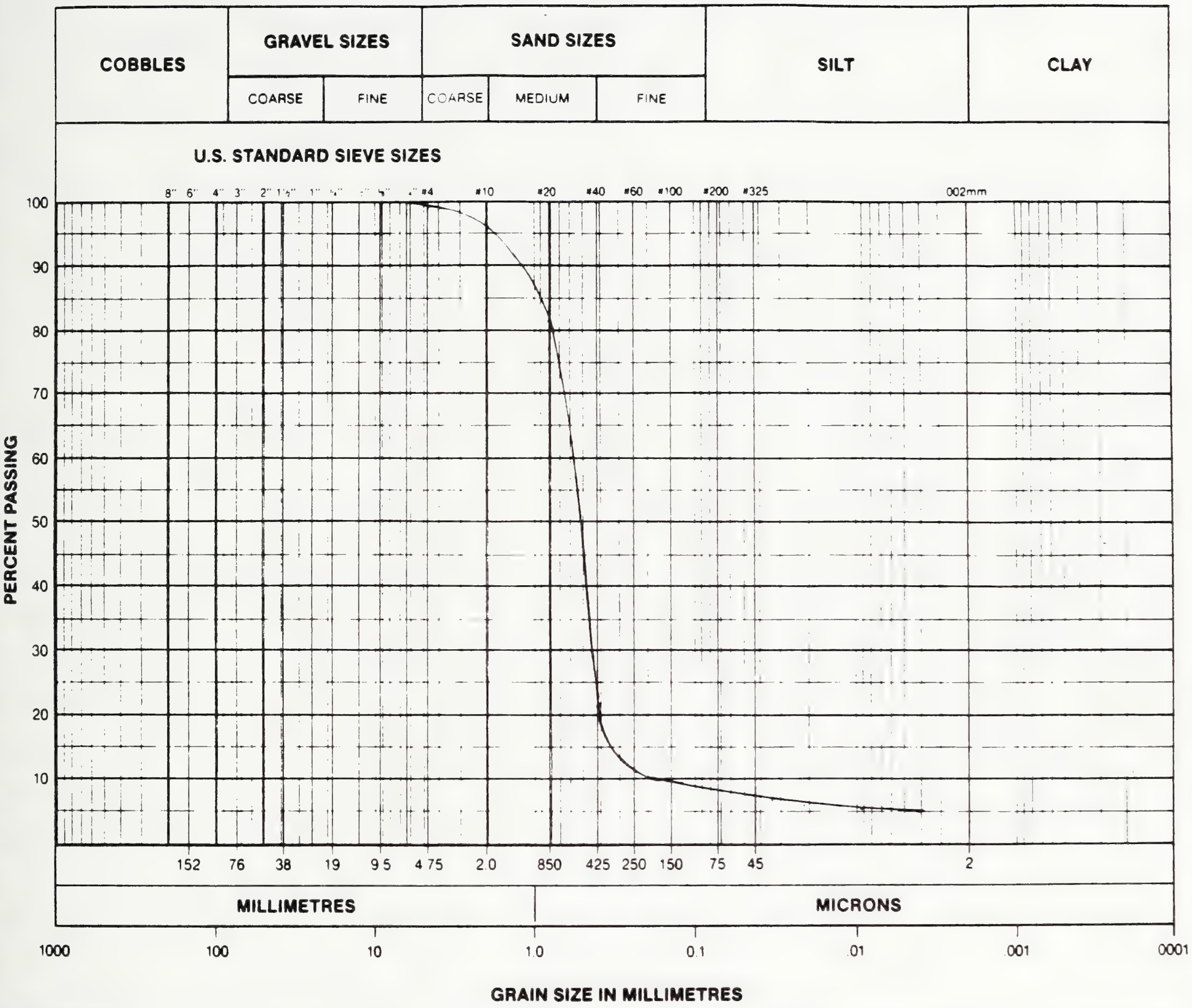
Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

Test Hole No. TH 1 Sample 1 Depth 2.3 – 2.8

GRAIN SIZE DISTRIBUTION

JOB NO. EG06558

S – 5878



REMARKS: ______

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY

D_{10} = ______ mm
D_{30} = ______ mm
D_{60} = ______ mm
C_U = ______ mm
C_C = ______ mm

GRAVEL ______ %
SAND ______ %
SILT ______ %
CLAY ______ %

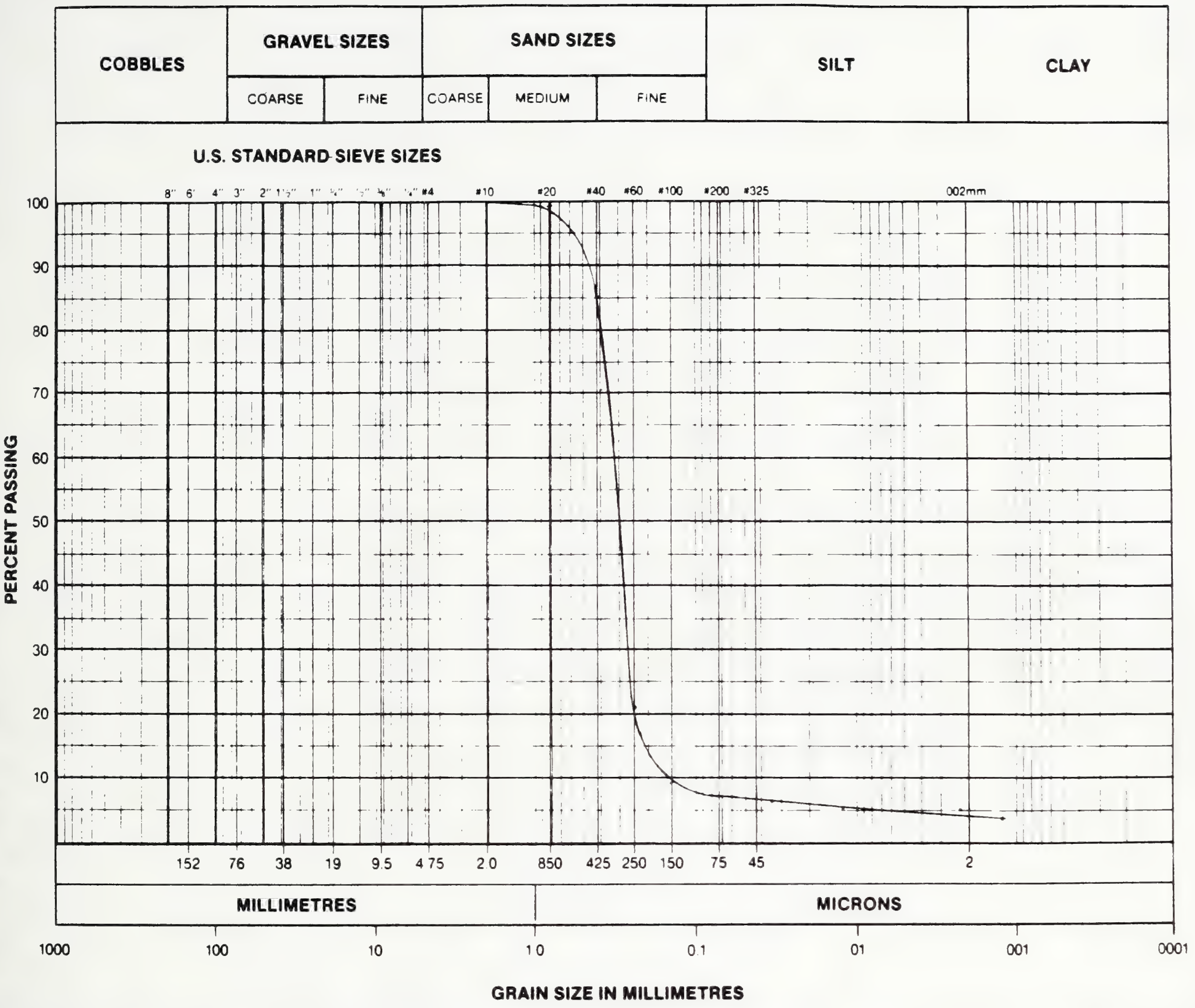
Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

Test Hole No. TH 4 Sample 2 Depth 2.3 - 2.8

GRAIN SIZE DISTRIBUTION

JOB NO. EG06558

S-5878



REMARKS: ____________________

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY

D_{10} =		mm	GRAVEL		%
D_{30} =		mm	SAND		%
D_{60} =		mm	SILT		%
C_U =		mm	CLAY		%
C_C =		mm			

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

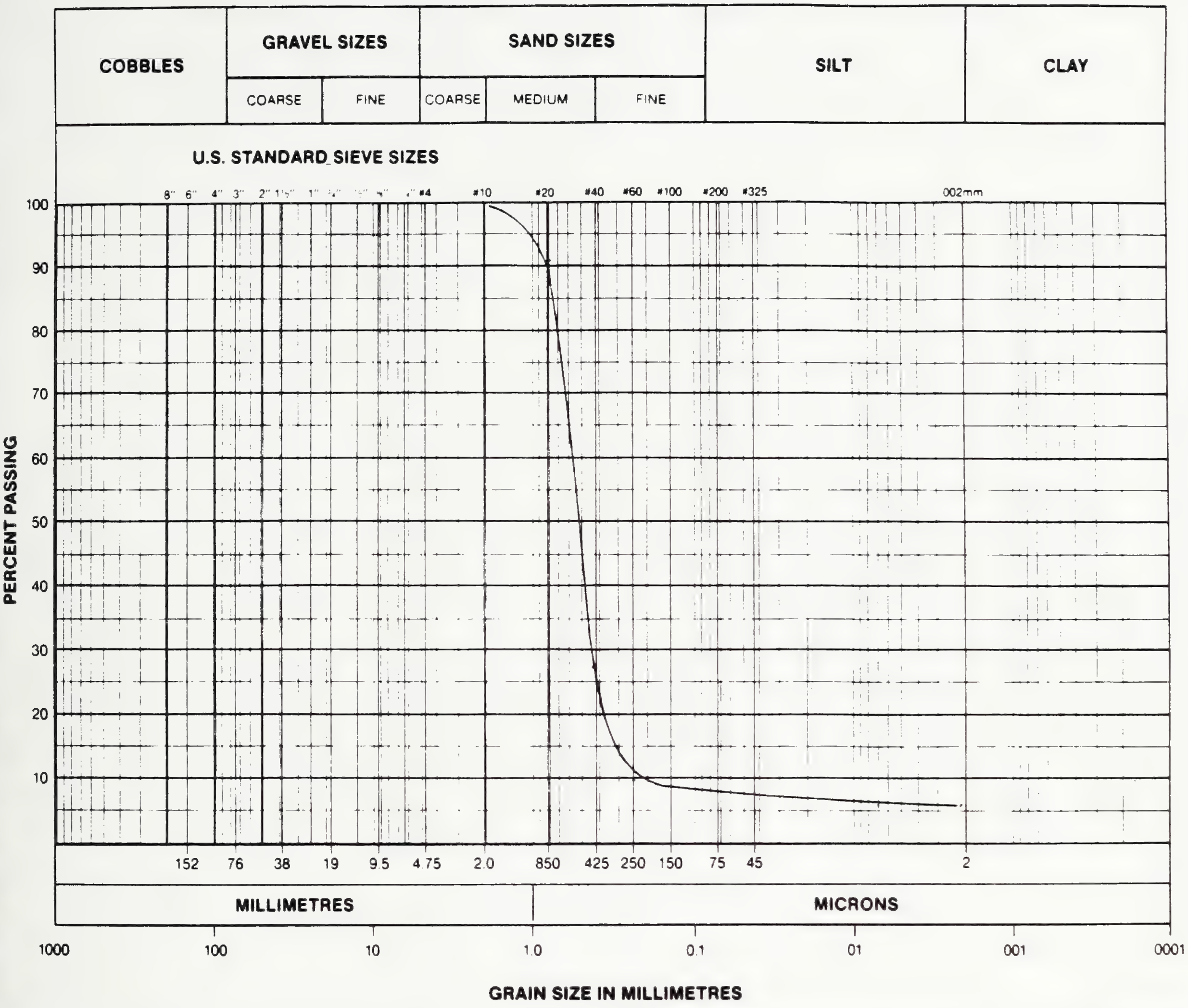
Test Hole No. TH 8 Sample 3 Depth 3.8 – 4.3

GRAIN SIZE DISTRIBUTION

JOB NO. EG06558

5-5878

HBLT 27-87/05



REMARKS:

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY

D_{10} =	mm	GRAVEL	%
D_{30} =	mm	SAND	%
D_{60} =	mm	SILT	%
C_U =	mm	CLAY	%
C_C =	mm		

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

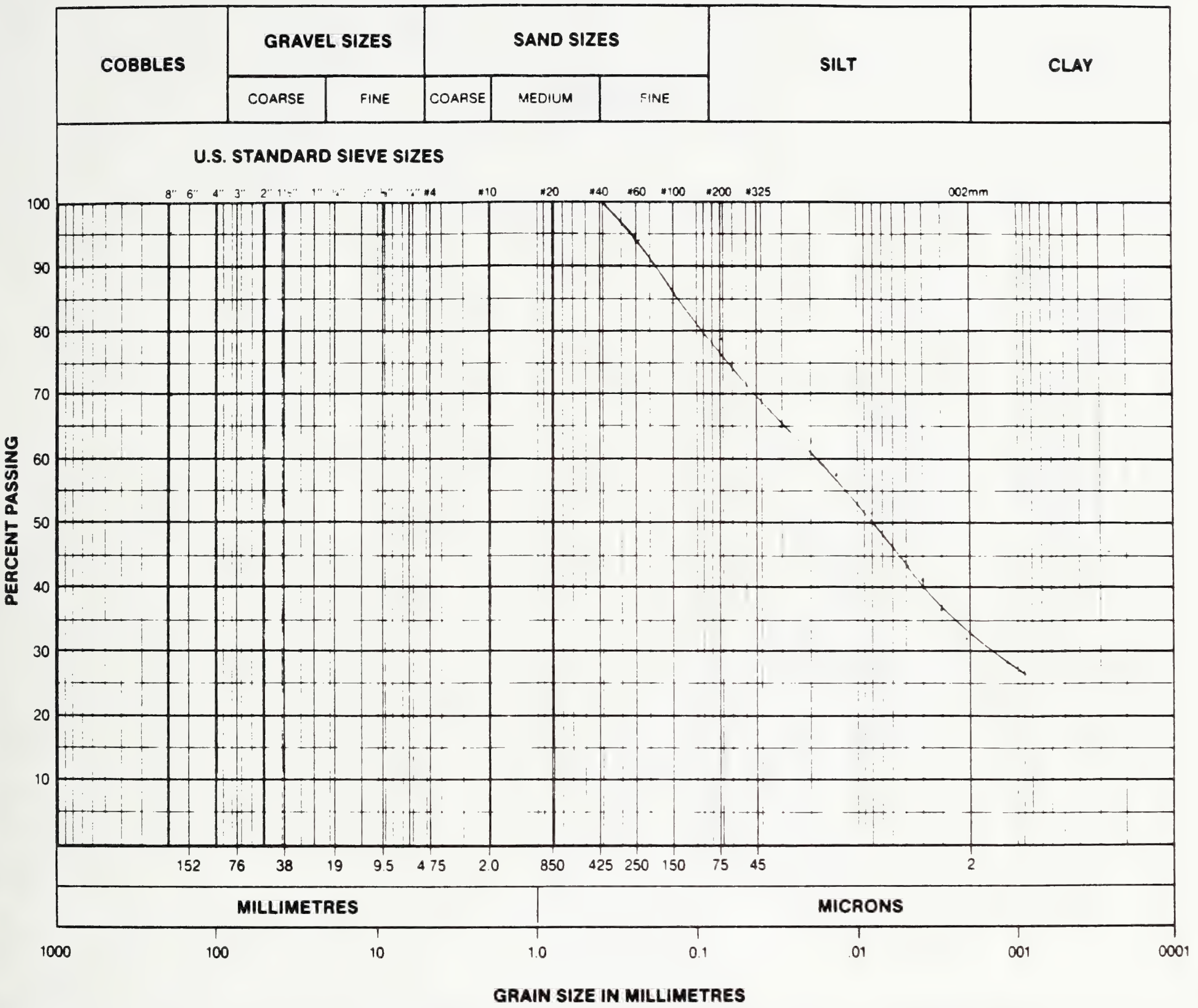
Test Hole No. TH 14 Sample 4 Depth 3.8 – 4.3

GRAIN SIZE DISTRIBUTION

JOB NO. EG06558

S – 5878

HBLT 27-87/05



REMARKS:

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY

D_{10} =	mm	GRAVEL	%
D_{30} =	mm	SAND	%
D_{60} =	mm	SILT	%
C_U =	mm	CLAY	%
C_C =	mm		

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

Test Hole No. TH 16 Sample 5 Depth 2.3 – 2.8

GRAIN SIZE DISTRIBUTION

JOB NO. EG06558

5-5878

HBLT 27-87/05

APPENDIX B

Explanation Sheets

EXPLANATION OF TERMS AND SYMBOLS

The terms and symbols used on the borehole logs to summarize the results of field investigation and subsequent laboratory testing are described in these pages.

It should be noted that materials, boundaries and conditions have been established only at the borehole locations at the time of investigation and are not necessarily representative of subsurface conditions elsewhere across the site.

TEST DATA

Data obtained during the field investigation and from laboratory testing are shown at the appropriate depth interval.

Abbreviations, graphic symbols, and relevant test method designations are as follows:

*C	Consolidation test	*ST	Swelling test
D_R	Relative density (formerly specific gravity)	TV	Torvane shear strength
Fines	Percentage by weight smaller than #200 sieve	VS	Vane shear strength (undisturbed-remolded)
k	Permeability coefficient	w	Natural moisture content (ASTM D 2216)
*MA	Mechanical grain size analysis and hydrometer test	w_l	Liquid limit (ASTM D 423)
N	Standard penetration test (CSA A119.1-60)	w_p	Plastic limit (ASTM D 424)
N_d	Dynamic cone penetration test	ε_f	Unit strain at failure
NP	Non plastic soil	γ	Unit weight of soil or rock
pp	Pocket penetrometer strength	γ_d	Dry unit weight of soil or rock
*q	Triaxial compression test	ρ	Density of soil or rock
q_u	Unconfined compressive strength	ρ_d	Dry density of soil or rock
*SB	Shearbox test	→	seepage
SO_4	Concentration of water-soluble sulphate	▼	observed water level

**The results of these tests usually are reported separately*

SOIL CLASSIFICATION AND DESCRIPTION

Soils are classified and described according to their engineering properties and behaviour.

The soil of each stratum is described using the Unified Soil Classification System[1] modified slightly so that an inorganic clay of "medium plasticity" is recognized.

The use of modifying adjectives may be employed to define the actual or estimated percentage range by weight of minor components. This is similar to a system developed by D.M. Burmister.[2]

The soil classification system is shown in greater detail on page 2.

SAMPLE TYPE — The type of sample is shown at the appropriate depth interval using the following abbreviations:

A	auger sample
B	block sample
C	rock core, or frozen soil core
D	drive sample
P	pitcher tube sample
U	tube sample (usually thin-walled)
W	wash or air return sample
O	other (see report text)
⧅	indicates no sample recovery

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[1] "Unified Soil Classification System", Technical Memorandum 3-357 prepared for Office, Chief of Engineering, by Waterways Experiment Station, Vicksburg, Mississippi, Corps of Engineers, U.S. Army. Vol 1, March 1953.

[2] American Society for Testing and Materials. Procedures for Testing Soils, "Suggested Methods of Testing for Identification of Soils", 4th Ed; pp 221-233, Dec. 1964.

MODIFIED UNIFIED CLASSIFICATION SYSTEM FOR SOILS

MAJOR DIVISION			GROUP SYMBOL	GRAPH SYMBOL	COLOR CODE	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA	
COARSE-GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN 200 SIEVE)	GRAVELS MORE THAN HALF COARSE GRAINS LARGER THAN NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)	GW	○	RED	WELL GRADED GRAVELS, LITTLE OR NO FINES	$C_U = \frac{D_{60}}{D_{10}} > 4 \quad C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$	
			GP	○	RED	POORLY GRADED GRAVELS, AND GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS	
		DIRTY GRAVELS (WITH SOME FINES)	GM	●	YELLOW	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12%	ATTERBERG LIMITS BELOW "A" LINE OR P.I. LESS THAN 4
			GC	●	YELLOW	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES		ATTERBERG LIMITS ABOVE "A" LINE P.I. MORE THAN 7
	SANDS MORE THAN HALF FINE GRAINS SMALLER THAN NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)	SW	⁘	RED	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	$C_U = \frac{D_{60}}{D_{10}} > 6 \quad C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$	
			SP	⁘	RED	POORLY GRADED SANDS, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS	
		DIRTY SANDS (WITH SOME FINES)	SM	▥	YELLOW	SILTY SANDS, SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12%	ATTERBERG LIMITS BELOW "A" LINE P.I. LESS THAN 4
			SC	▨	YELLOW	CLAYEY SANDS, SAND-CLAY MIXTURES		ATTERBERG LIMITS ABOVE "A" LINE P.I. MORE THAN 7
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT PASSES 200 SIEVE)	SILTS BELOW "A" LINE NEGLIGIBLE ORGANIC CONTENT	$W_L < 50\%$	ML	▥	GREEN	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY SANDS OF SLIGHT PLASTICITY	CLASSIFICATION IS BASED UPON PLASTICITY CHART (see below)	
		$W_L > 50\%$	MH	▥	BLUE	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY SOILS		
	CLAYS ABOVE "A" LINE ON PLASTICITY CHART NEGLIGIBLE ORGANIC CONTENT	$W_L < 30\%$	CL	▨	GREEN	INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY, OR SILTY CLAYS, LEAN CLAYS		
		$30\% < W_L < 50\%$	CI	▨	GREEN-BLUE	INORGANIC CLAYS OF MEDIUM PLASTICITY, SILTY CLAYS		
		$W_L > 50\%$	CH	▨	BLUE	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS		
	ORGANIC SILTS & CLAYS BELOW "A" LINE ON CHART	$W_L < 50\%$	OL	▥	GREEN	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY	WHENEVER THE NATURE OF THE FINE CONTENT HAS NOT BEEN DETERMINED, IT IS DESIGNATED BY THE LETTER "F", E.G. SF IS A MIXTURE OF SAND WITH SILT OR CLAY	
		$W_L > 50\%$	OH	▨	BLUE	ORGANIC CLAYS OF HIGH PLASTICITY		
HIGHLY ORGANIC SOILS			Pt	▩	ORANGE	PEAT AND OTHER HIGHLY ORGANIC SOILS	STRONG COLOR OR ODOR, AND OFTEN FIBROUS TEXTURE	

SPECIAL SYMBOLS

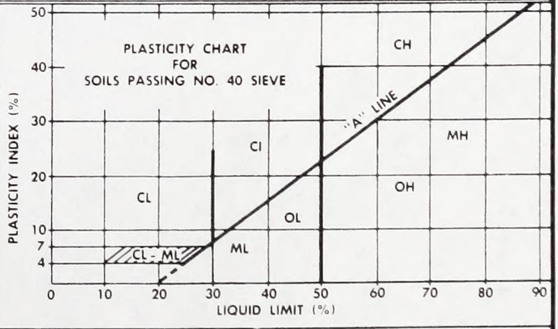
▨	BEDROCK (Undifferentiated)	▦	VOLCANIC ASH

SOIL COMPONENTS

FRACTION	U S STANDARD SIEVE SIZE		DEFINING RANGES OF PERCENTAGE BY WEIGHT OF MINOR COMPONENTS	
	PASSING	RETAINED	PERCENT	DESCRIPTOR
GRAVEL				
coarse	76 mm	19 mm	50 - 35	and
fine	19 mm	No 4	35 - 20	some
SAND				
coarse	4.75 mm	2.00 mm	20 - 10	little
medium	2.00 mm	425 μm		
fine	425 m	75 μm	10 - 1	trace
SILT (non plastic) or CLAY (plastic)	75 μm			

OVERSIZE MATERIAL

Rounded or subrounded COBBLES 76 mm to 203 mm BOULDERS > 203 mm	Not rounded ROCK FRAGMENTS > 76 mm ROCKS > 0·76 cubic metre in volume



1. ALL SIEVE SIZES MENTIONED ON THIS CHART ARE U.S. STANDARD, A.S.T.M. E.11.
2. BOUNDARY CLASSIFICATIONS POSSESSING CHARACTERISTICS OF TWO GROUPS ARE GIVEN COMBINED GROUP SYMBOLS, E.G. GW-GC IS A WELL GRADED GRAVEL SAND MIXTURE WITH CLAY BINDER BETWEEN 5% AND 12%.

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